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CROSSFIX ERRORS OF DIRECTIONAL
ACOUSTIC SENSORS IN A MEDIUM WITH A CONSTANT
HORIZONTAL VELOCITY GRADIENT

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**CROSSFIX ERRORS OF DIRECTIONAL ACOUSTIC SENSORS
IN A MEDIUM WITH A CONSTANT HORIZONTAL
VELOCITY GRADIENT**

by

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ABSTRACT

An investigation was made of the magnitude of the bearing and distance errors which result from two passive directional acoustic sensors obtaining a crossfix on a target in a medium with a constant horizontal velocity gradient. Results are tabulated in Appendix III. For the conditions considered, the errors were found to be small in relation to the target range but became appreciable in absolute value at very large target ranges. However, with a knowledge of the horizontal velocity gradient, sensor separation, sensor axis orientation, apparent target range and apparent target bearing the errors could be predicted. Further, by proper sensor orientation, the errors could be minimized.

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1. Introduction.

Straight-line propagation of sound is to be expected only if the velocity of propagation is constant throughout the medium. Because of the heterogeneous nature of the ocean, this condition is usually not met and marked deviations from straight line propagation have been observed to occur.

The principle factors that influence the velocity of sound in sea water and therefore result in refraction of the sound ray are temperature, salinity, and depth. Variations in salinity are of importance near the mouths of large rivers where appreciable amounts of fresh water run into the sea, in the vicinity of large ocean currents such as the Gulf Stream, and in water close to the surface where rain and evaporation will have a maximum effect. However, by far the most important factors influencing variations in the speed of sound are differences in temperature and depth of the points through which the sound ray passes.

A considerable amount of work has been done investigating the refraction of sound rays caused by variations of temperature with depth. The aim of these studies has been to increase the detection capability of sensors by placing them in such a manner that "shadow zones" are either eliminated or caused to be as far from the sensors as possible. Further, the studies have investigated ways to make optimum use of sound "channels" caused by having a layer of water in which the sound velocity is lower than that both above and below it.

However, once a detection has been made by two directional acoustic sensors and the resulting fix plotted, very little has been done to determine by how much this apparent fix is displaced from the actual target location due to horizontal temperature gradients. Although these gradients

are normally small in relation to the vertical ones, there are certain areas near ocean currents, such as the Gulf Stream, where they do become appreciable and thus could possibly cause significant bearing errors in crossfixes. Further, as the range at which sensors can detect a target is increased through technical improvements and making use of "channeling", bearing errors could become significant.

One investigation of the fixing errors which could result from horizontal temperature gradients considered the case where there was a sharp vertical boundary between two bodies of water having different sound propagation velocities. [6] The next logical condition to consider is a constant velocity gradient. Therefore an investigation of the effect of a constant gradient is presented in the ensuing sections of this thesis.

2. Theoretical Background.

Sound energy takes the form of disturbances of the pressure and density of some medium. Therefore, the basic relationships between impressed forces and the resulting changes in pressure and density are applicable to the theory of sound propagation in water. However, the solution of the differential equations applicable to pressure transmission phenomena requires a knowledge of certain initial and boundary conditions. This knowledge is almost always lacking for sound transmission in sea water. Fortunately, it is possible to discuss some of the important characteristics of sound propagation in sea water without considering the frequency and wave structure of the sound. For such discussions the wave can be thought of as a beam or ray, and the discussion is concerned only with the geometry of the situation.

The ray concept is based on the assumption that sound energy is transmitted along curved paths, called rays, which are straight lines in

all parts of the medium where the velocity of sound is a constant, and which curve according to certain rules in parts where the velocity of sound is changing. However, in making use of the ray path approach to the solution of sound propagation problems it must be kept in mind that certain assumptions are implicit in this technique. If the conditions imposed by these assumptions do not apply, the use of the method is not valid. These assumptions are:

(a) The direction of the ray must not change much over a distance of one wave length; that is, the radius of curvature of the rays must be large in relation to the wavelength.

(b) The velocity of sound must not change appreciably over the distance of one wavelength. [7]

The simplest continuous velocity gradient which can be considered is one which is a constant. This particular gradient has the interesting property of resulting in a sound ray path which is the arc of a circle. This fact is easily shown by a consideration of the following:

Assume that the velocity of sound, V , at a point (x, y) , is a linear function of the distance of the point from the origin in the x direction; i.e. $V_p = V_o + gx$, where V_p and V_o are the velocities of sound at some point P and the origin respectively, and g is the horizontal velocity gradient, a constant. Figure 1 illustrates the situation under consideration.

In the diagram the velocity gradient is in the horizontal (x) direction. The gradient at any point P with coordinates (x, y) is, by definition,

$$\frac{dV}{dx} = g.$$

By integrating this expression and specifying that the x distances shall be measured from a vertical line through the points where the velocity is zero it is possible to avoid the introduction of a constant of integration and obtain the expression

$$(2-1) \quad x = \frac{V}{g}$$

Then, recalling Snell's Law

$$(2-2) \quad \frac{V}{\cos \theta} = K$$

where θ is the angle measured from the boundary of the medium (an iso-velocity line in this case) to the ray under consideration and K is the Snell's Law constant for this ray, equations (2-1) and (2-2) can be combined by eliminating V to obtain

$$(2-3) \quad x = \frac{K}{g} \cos \theta$$

Differentiating this expression yields

$$(2-4) \quad dx = - \frac{K}{g} \sin \theta d \theta$$

But, from elementary analytical geometry $dx = \tan \theta dy$ (note that in this situation angles are measured clockwise from the y axis), thus (2-4) becomes

$$(2-5) \quad dy = - \frac{K}{g} \cos \theta d \theta$$

Now integrating (2-5) and specifying that vertical distances, y, are to be measured from the horizontal line through the point at which $\theta = 0$ yields

$$(2-6) \quad y = - \frac{K}{g} \sin \theta$$

By squaring (2-3) and (2-6), then adding them, the following result

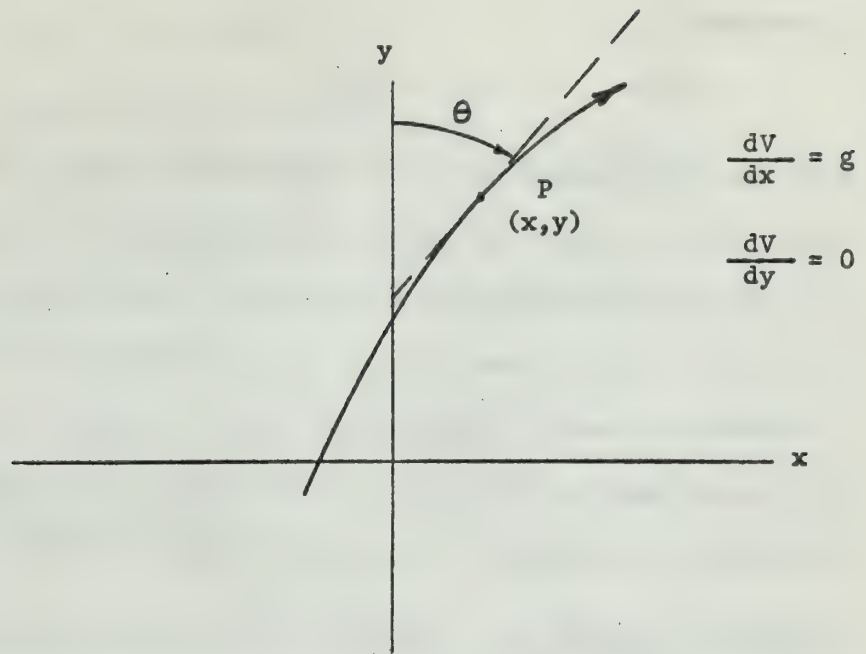


Figure 1. General Ray Path Geometry

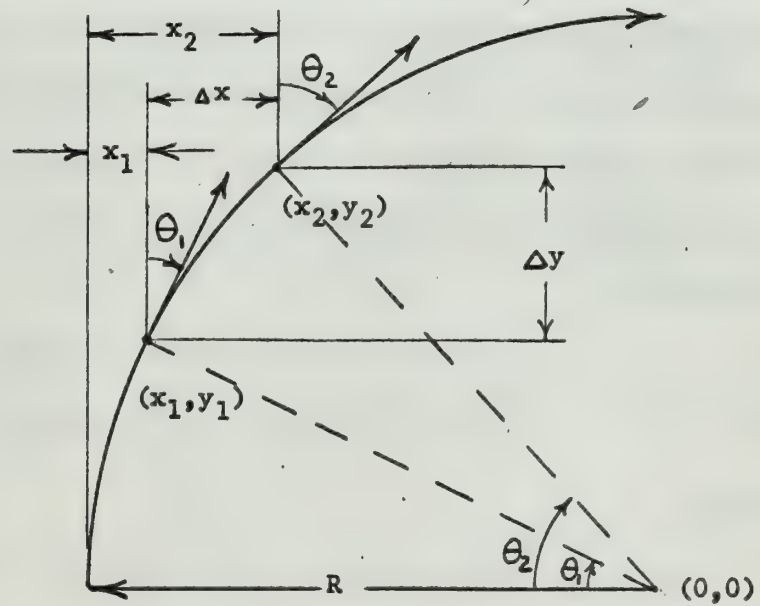


Figure 2. Constant Gradient Ray Path Geometry

is obtained:

$$(2-7) \quad x^2 + y^2 = \left(\frac{K}{g}\right)^2$$

This is easily recognized as the equation of a circle of radius $\frac{K}{g}$.

The circle is centered at the origin specified in the foregoing paragraphs as being the intersection of a horizontal line through the point where $\theta = 0$ and a vertical line through the points where $V = 0$.

Since the Snell's Law constant, K , at any point is the ratio of the velocity of sound at that point to the cosine of the angle of inclination of the ray at that point, it is readily seen that the radius of the circle is actually $\frac{V_p}{g \cos \theta_p}$, i.e. the ratio of the velocity of sound at that point to the gradient times the cosine of the angle of inclination of the ray at that point. Thus, if the velocity and angle of inclination of the ray are known at some point, the coordinates and angle of inclination of the ray are completely specified for the total path of the ray.

By making use of the fact that a constant velocity gradient results in rays that are arcs of circles some useful relationships can be obtained for tracing the path of a sound ray through the water. Consider a circle of radius R with the points (x_1, y_1) and (x_2, y_2) as in Figure 2. By geometry,

$$x_1 = R - R \cos \theta_1 = R(1 - \cos \theta_1)$$

$$x_2 = R - R \cos \theta_2 = R(1 - \cos \theta_2)$$

Therefore

$$(2-8) \quad \begin{aligned} \Delta x &= x_2 - x_1 = R(1 - \cos \theta_2) - R(1 - \cos \theta_1) \\ &= R(\cos \theta_1 - \cos \theta_2) \end{aligned}$$

Now, for a linear velocity gradient, g , the velocity, V_2 , at a point, (x_2, y_2) , may be found from the following relationship:

$$V_2 = V_1 + g \Delta x$$

where V_1 is the velocity at the point, (x_1, y_1) .

Thus

$$(2-9) \quad \Delta x = \frac{V_2 - V_1}{g}$$

Equating (2-8) and (2-9) yields

$$(2-10) \quad R(\cos \theta_1 - \cos \theta_2) = \frac{V_2 - V_1}{g}$$

Solving this expression for R,

$$(2-11) \quad R = \frac{V_2 - V_1}{g(\cos \theta_1 - \cos \theta_2)}$$

But, from Snell's Law,

$$(2-12) \quad \cos \theta_1 = \frac{V_1}{V_2} \cos \theta_2.$$

Substituting (2-12) into (2-11) yields

$$(2-13) \quad R = \frac{V_2 - V_1}{g \left(\frac{V_1}{V_2} \cos \theta_2 - \cos \theta_2 \right)} = \frac{V_2 - V_1}{g \cos \theta_2 \left(\frac{V_1}{V_2} - 1 \right)}$$

$$= \frac{V_2 - V_1}{g \cos \theta_2 \left(\frac{V_1 - V_2}{V_2} \right)} = - \frac{V_2}{g \cos \theta_2}$$

Similarly,

$$(2-14) \quad \Delta y = y_2 - y_1 = R \sin \theta_2 - R \sin \theta_1 = R(\sin \theta_2 - \sin \theta_1)$$

$$= R \left[2 \sin \frac{1}{2} (\theta_2 - \theta_1) \cos \frac{1}{2} (\theta_2 + \theta_1) \right]$$

But, from (2-8)

$$R = \frac{\Delta x}{\cos \theta_1 - \cos \theta_2}$$

Thus, substituting this into (2-14)

$$\begin{aligned}
 y &= \left(\frac{\Delta x}{\cos \theta_2 - \cos \theta_1} \right) \left[2 \sin \frac{1}{2}(\theta_2 - \theta_1) \cos \frac{1}{2}(\theta_2 + \theta_1) \right] \\
 &= \left[\frac{\Delta x}{-2 \sin \frac{1}{2}(\theta_1 + \theta_2) \sin \frac{1}{2}(\theta_1 - \theta_2)} \right] \\
 &\quad \left[2 \sin \frac{1}{2}(\theta_2 - \theta_1) \cos \frac{1}{2}(\theta_2 + \theta_1) \right] \\
 &= \frac{\Delta x \left[-\sin \frac{1}{2}(\theta_1 - \theta_2) \cos \frac{1}{2}(\theta_1 + \theta_2) \right]}{\left[-\sin \frac{1}{2}(\theta_1 + \theta_2) \sin \frac{1}{2}(\theta_1 - \theta_2) \right]}
 \end{aligned}$$

Simplifying this expression by means of a trigonometric identity yields

$$(2-15) \quad y = \Delta x \cot \left(\frac{\theta_1 + \theta_2}{2} \right)$$

Equation (2-15) is the basic equation used in the model described in section 3 which is used to trace the sound rays through the water.

It should be noted that the minimum radius of the circle, as computed from equation (2-13), describing the path of a sound ray is obtained when $\cos \theta_2$ and the gradient, g , are both a maximum. This means that for the model described in section 3 the minimum radius will occur when $\theta = 0^\circ$ and the velocity gradient is 0.0005 meter/sec per meter. This radius will be $\frac{1500}{(.0005)(1)} = 3 \times 10^6$ meters. Since the wavelength of a 200 cycle/sec signal (approximately the frequency of a low frequency noise source on a medium speed submarine [4]) is about 7.5 meters it is readily seen that the conditions of assumption (a), that the radius of curvature must be large in relation to the wavelength, are met and the use of the ray path method is valid. Further, the conditions of assumption (b), that the velocity of sound does not change appreciably over one wavelength, are fulfilled since the velocity only changes by $\frac{7.5 \times .0005}{1500} = 2.5 \times 10^{-6} =$

.00025% in a distance of one wavelength.

3. The Model.

In modeling the problem under investigation the following assumptions were made:

a. A detection had been made by two directional acoustic sensors and the apparent fix plotted.

b. There was no change in horizontal gradient with depth, therefore the amount of bending of the ray was the same at any depth and the problem could be reduced to one of finding the ray path in a horizontal plane only. (It is realized that the horizontal gradient does, in actuality, change slightly with depth, thus all results are approximations. However, to treat the problem in three dimensions would require an amount of time exceeding that available for the conduct of the present investigation.)

c. The velocity gradient was a constant in one direction and zero in a direction perpendicular to this one. This allowed the use of the circle approximation to the path of the sound rays.

d. The directional acoustic sensor had no bearing error. To add this to the problem would obscure the effect of the temperature gradient.

Figure 3 is an illustration of the situation studied. An apparent target was located at XAPP, YAPP, the apparent fix obtained from sensors A and B located at X1, Y1, and XX1, YY1 respectively. The bearings of the apparent target from sensors A and B were BRGA and BRGB respectively. To relate the fix to some common reference point, an "origin" was chosen at the midpoint of a line joining the two sensors. The bearing and range of the apparent target from this point were BRGP and RAPP. However, due to the horizontal velocity gradient, some bending of the sound rays

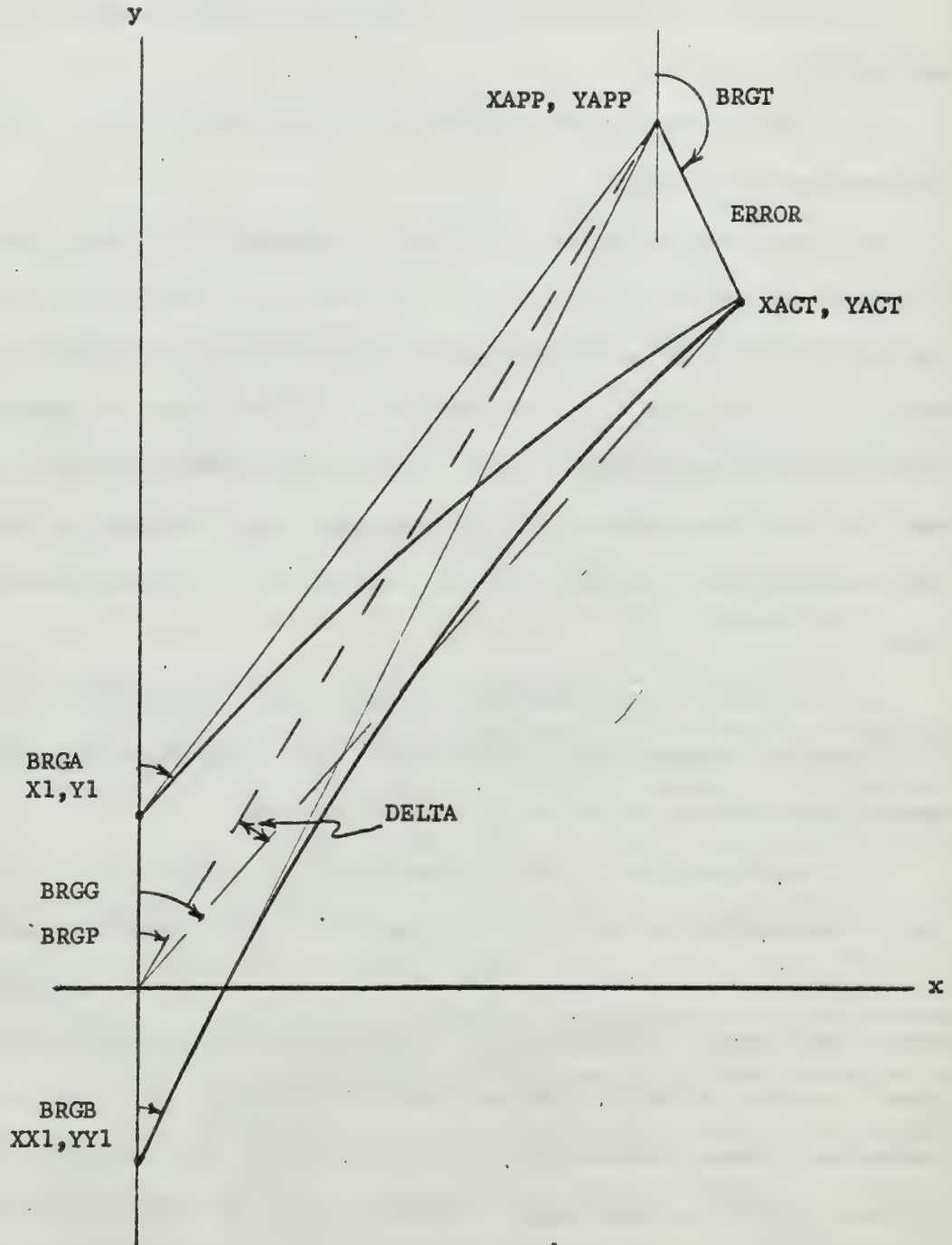


Figure 3. Computer Program Geometry

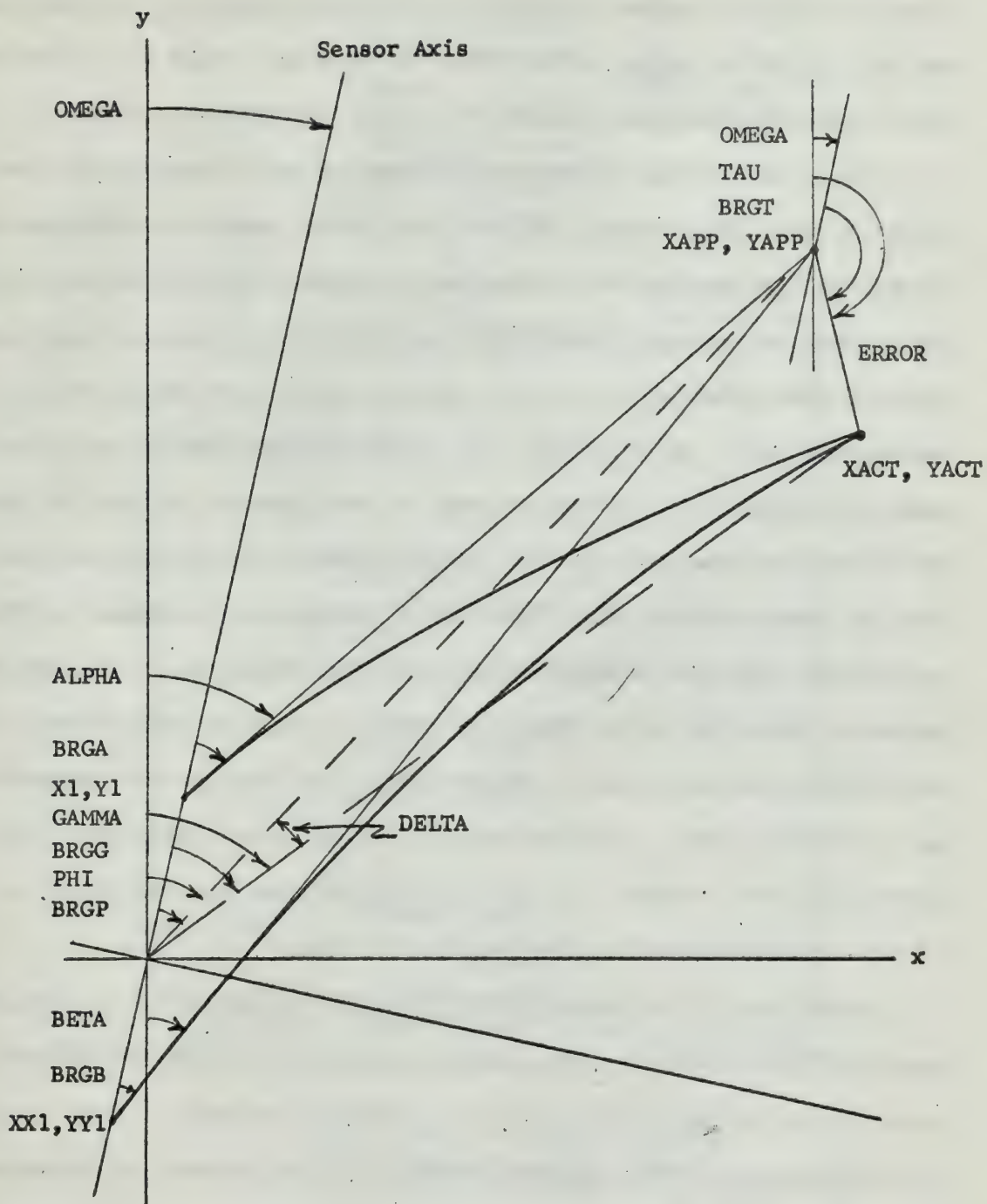


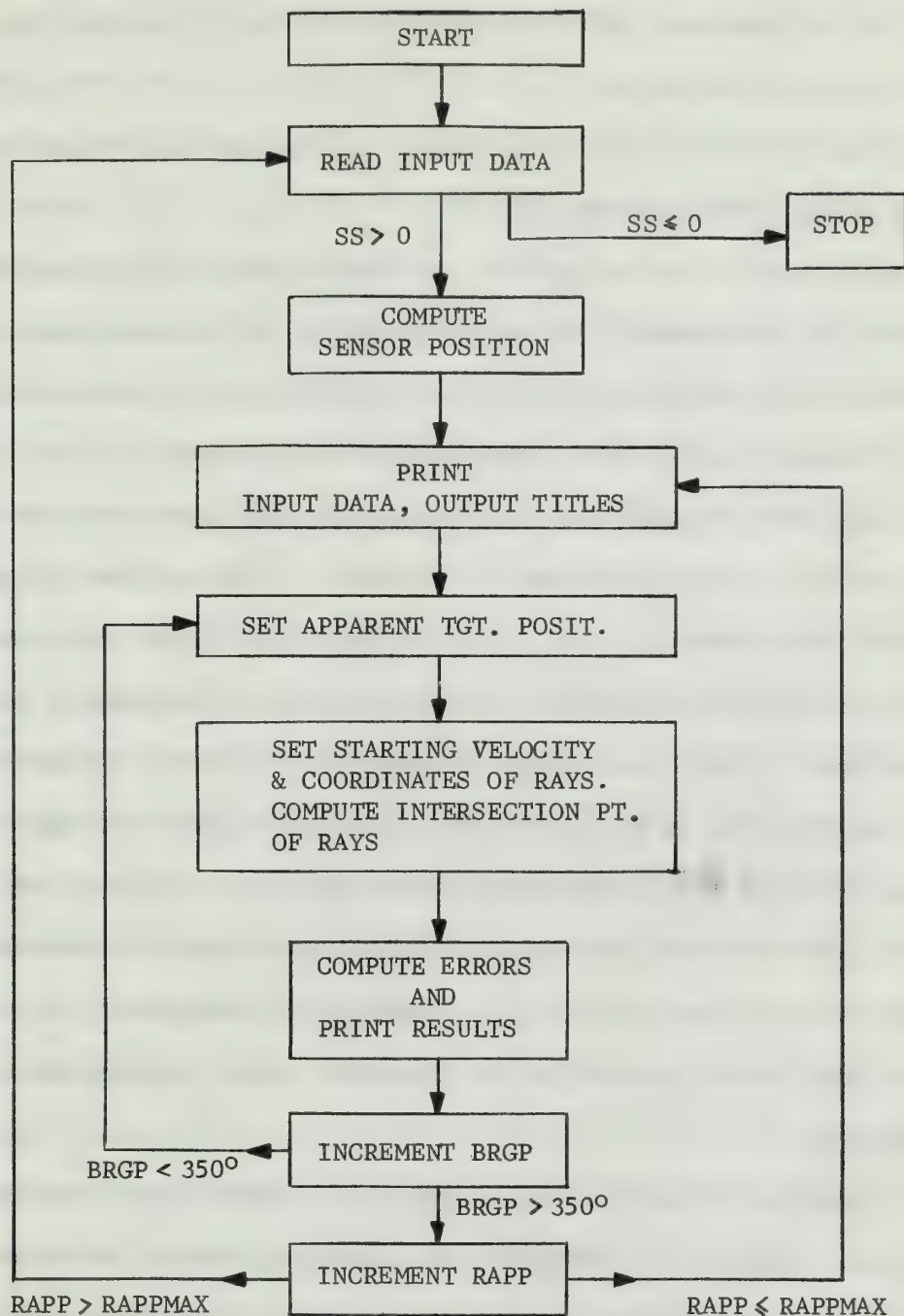
Figure 4. Computer Program Geometry (Sensor Axis Rotated)

occurred and the actual target was located at XACT, YACT. The bearing and range of the actual target from the origin were BRGG and RACT. The distance from the apparent target to the actual target was the ERROR and the bearing of the actual target from the apparent target was called BRGT. RNGERR was the difference between the actual and apparent ranges.

If the sensors had always been located along an isovelocity line, Figure 3, with the bearings and distances shown, would be sufficient to illustrate the geometry of the problem. However, the inclination, by an angle OMEGA, of an axis through the two sensors with respect to an isovelocity line resulted in a need to define angles with respect to an isovelocity line. By selecting the x and y axes perpendicular to and along an isovelocity line respectively it was possible to make the best use of the fact that the velocity gradient was a constant in one direction and zero in the other. These angles measured with respect to the isovelocity line were assigned Greek names corresponding to the letter appearing after the prefix BRG; i.e. BRGA, the bearing with respect to an axis through the two sensors, became ALPHA, the bearing with respect to an isovelocity line. The Greek letter bearings equal OMEGA plus the appropriate BRG. Figure 4 illustrates the problem when the sensor axis is rotated with respect to the isovelocity line.

Making use of the relationships developed in section 2 relating the sound ray path to the arc of a circle, a computer program was written to trace the actual path of the sound ray through the water. Thus, given initial bearings of the apparent target from two sensors, it calculated the actual target position from the point of intersection of the actual ray paths. The program is included in Appendix I.

The "mechanics" of the program are illustrated in Figure 5, a flow



BRGP = Apparent Target Bearing
 RAPP = Apparent Target Range
 RAPPMAX = Maximum RAPP to be Considered
 SS = Sensor Separation

Figure 5. Flow Chart for Program

chart for the program. For the reader interested in greater detail a more detailed block diagram may be found in Appendix II. The Roman numerals in the blocks of Appendix II correspond to the numerals in the left hand margin of the program in Appendix I.

For a given velocity gradient and sensor separation an apparent target position was assumed. From this position the apparent bearings and distance of the target from the origin and the sensors was calculated. Then the actual position of the target was determined by calculating the actual ray paths through the water and computing their point of intersection. Finally, the errors were calculated. A new apparent target position was then assumed and the calculations repeated for this new position. Apparent target positions were assumed for each 10 degrees of bearing from an axis through the sensors (except for the 0 and 180 degree positions where no fix is possible) and for various apparent ranges to a maximum range of five times the sensor separation. Further, as stated earlier, the angle of inclination of the axis through the sensors to the isovelocity line was varied in 10 degree increments from 0 to 90 degrees for selected sensor separation and apparent range combinations.

4. Results.

To evolve a means for estimating the crossfix errors resulting from horizontal temperature gradients, the effect of the following parameters on the errors was studied using the model described in section 3:

- (a) target bearing
- (b) magnitude of velocity gradient
- (c) sensor separation
- (d) target apparent range
- (e) sensor axis orientation

The range of values over which the parameters were varied was as follows:

(a) target bearing (BRGP): 10° increments from 10° to 350° relative to the sensor axis except for 180° where no fix was possible due to target alignment with the sensor axis.

b) velocity gradient (VGRAD): .0001 to .0005 meter/second per meter. These were found to be the approximate maximum velocity gradients which exist over long (about 100 km.) distances in the deep sound channel and over short (about 40 km.) distances near the surface at the Gulf Stream.

[5]

(c) sensor separation (SS): 1 km. to 400 km. These were considered to be the minimum and maximum feasible for obtaining a crossfix.

(d) target apparent range (RAPP): 1 km. to 2,000 km. but never less than .1 nor more than 5 times the sensor separation since beyond these values the target bearings from the sensors become almost equal.

(e) sensor axis orientation (OMEGA): sensor axis 0° to 90° from the isovelocity line in 10° increments.

As might be expected, the errors were found to be small in relation to the target distance from the sensors but to be appreciable in absolute value for targets at long ranges from the sensors or in areas where a large velocity gradient existed. It was found that the errors were predictable and that they could be minimized by proper sensor orientation. The results are summarized in sections 4.1 through 4.8 and depicted graphically in Figures 6 through 20. Although all of the computer output data used in plotting the graphs for the figures is not included, samples of the data which illustrate particular effects are included in Appendix III. Also, it should be noted that the abbreviations used in

the figures are defined at the beginning of the computer program in Appendix I.

4.1 Effect of Target Bearing.

Figure 6 illustrates the influence of target bearing (BRGP) on the magnitude of the crossfix errors. As the figure and the data in Tables 1, 2 and 3 show, for a given velocity gradient condition the error was very much influenced by target bearing from the sensor axis when the sensor axis was oriented along an isovelocity line. However, when the sensor axis was at 90° to the isovelocity line, i.e. along the velocity gradient line where $\text{OMEGA} = 90$, target bearing had almost no effect on the error. The influence of sensor axis orientation is discussed further in section 4.5. For the case where the sensor axis was along an isovelocity line the errors were seen to increase rapidly as the target bearings approached the sensor axis. As discussed in section 2, this was due to the fact that the radius of curvature of the sound ray approaches its minimum value as the angle which the ray makes with the isovelocity line approaches zero.

4.2 Effect of Velocity Gradient.

Figure 6 also illustrates the influence of velocity gradient (VGRAD) on the magnitude of the cross-fix errors. As the figure and the data in Tables 1, 2 and 3 show, the errors were a linear function of the velocity gradient, i.e. the velocity gradient of .0005 m/sec per meter resulted in errors 5 times larger than those for a gradient of .0001. Although Figure 6 depicts the particular case of a 2 km. sensor separation and 10 km. target range, the effect which it illustrates was found to be the same for all sensor separation and target range combinations examined. The plot for the 90° rotation of the sensor axis from an isovelocity line

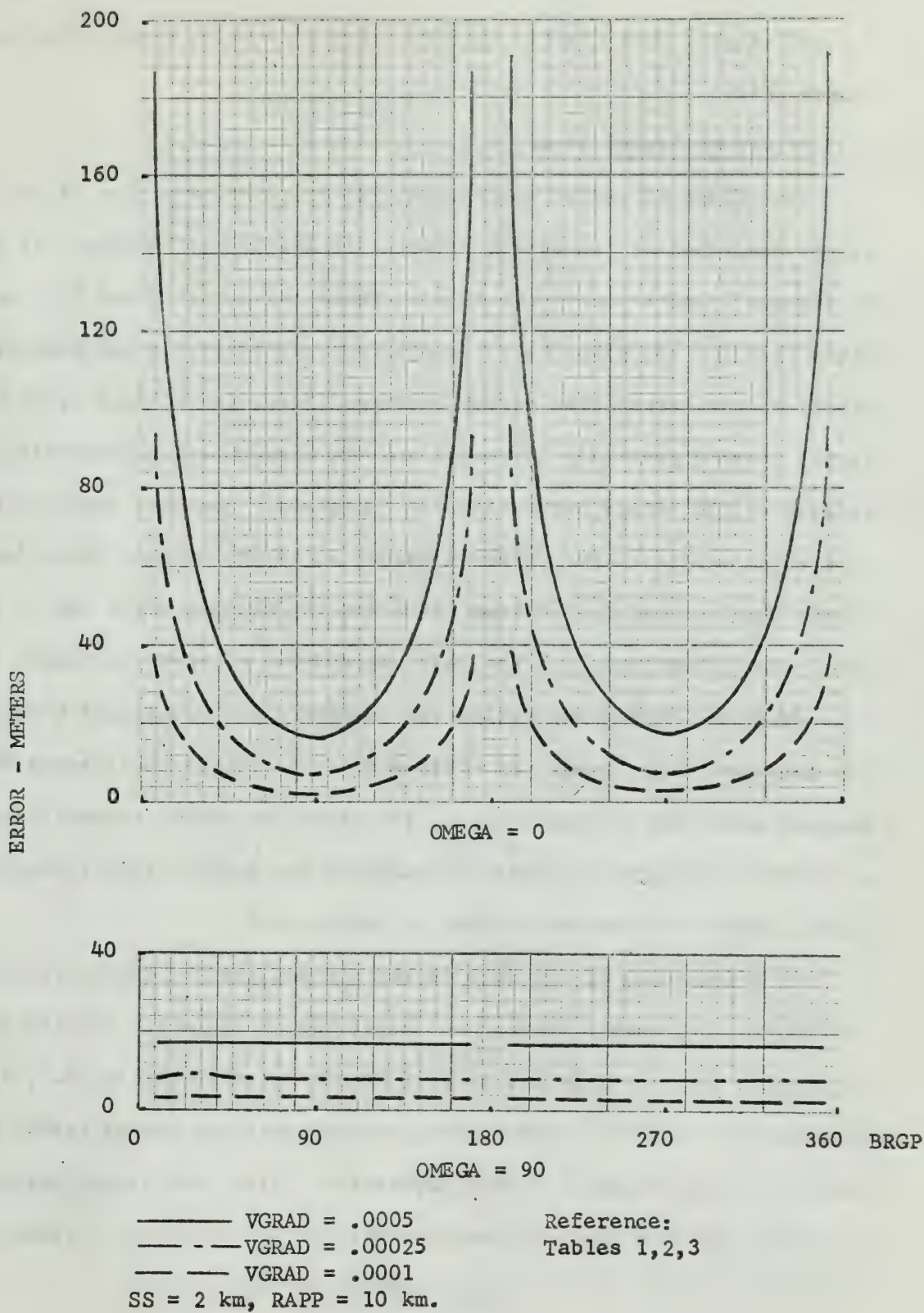


Figure 6. Effect of Velocity Gradient

illustrates the linear relationship between velocity gradient and crossfix errors even more clearly than the plot for the 0° rotation of the sensor axis.

4.3 Effect of Sensor Separation.

The effect of sensor separation (SS) on crossfix errors is not as simply described as the effect of velocity and target bearing. As shown in Figures 7 and 8 and by the data in Tables 4, 5, 6, 7, and 8 it was found that for any given target range, sensor separation had much less effect on the errors than target bearing. Also, the minimum error due to target bearing generally increased and the maximum error generally decreased as the sensor separation was increased. However, when the sensor separation was twice the apparent target range the maximum error due to target bearing was at a minimum value and the minimum error was at a maximum value, thus there was the least dependence of error on target bearing. When the sensor separation was increased to values more than twice the apparent target range the minimum error continued to increase and the maximum error now increased also. The effect of sensor separation on crossfix errors when the sensor separation was greater than twice the target range is discussed further in section 4.8.

An examination of the data in the figures and the tables revealed no simple relationship between the magnitude of the error and the sensor separation per se. However, as will be discussed in section 4.6, it was possible to formulate an estimating relationship for errors based on the ratio of target range to sensor separation. Also, the large variation in error for the case where the sensors were 10 km. apart and oriented 90° to the isovelocity line will be discussed in section 4.8.

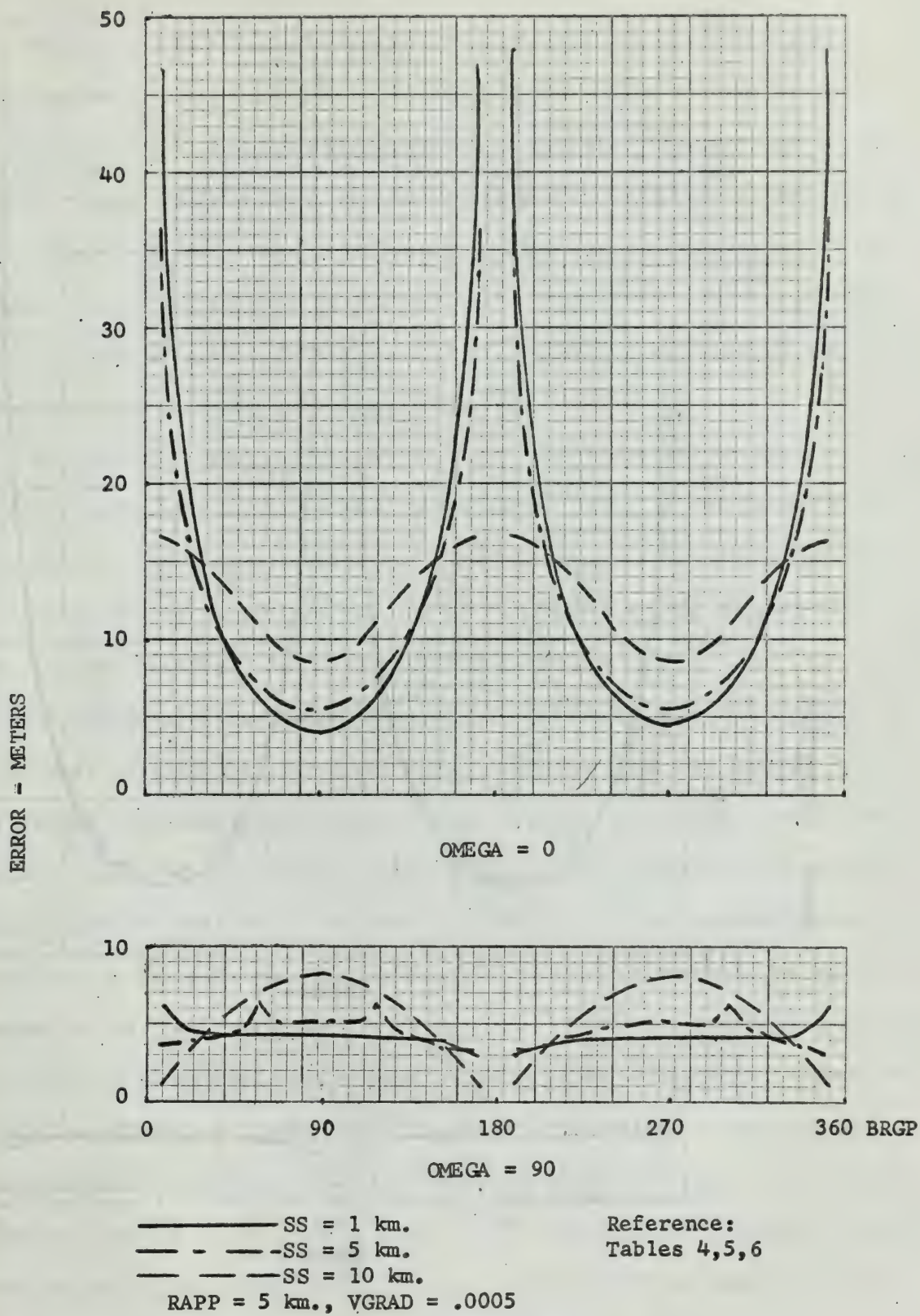


Figure 7. Effect of Sensor Separation

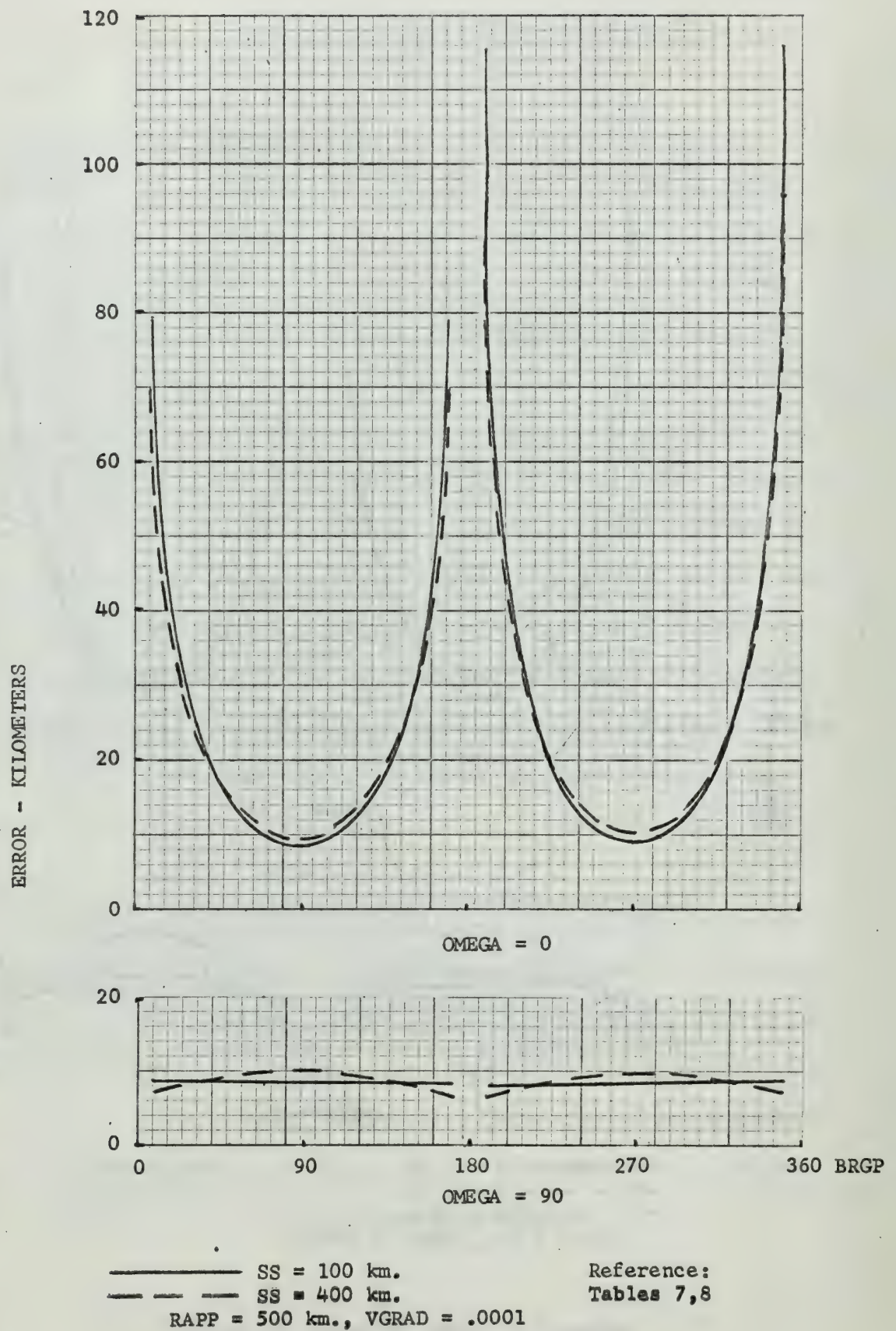


Figure 8. Effect of Sensor Separation

4.4 Effect of Target Range.

Figures 9 and 10 show the dependence of crossfix errors on target range (RAPP). Samples of the data used to plot the graphs may be found in Tables 4, 8-12, and 13. Figure 9a shows the absolute error as a function of target bearing for three target ranges and a sensor separation of 1 km. Figure 9b shows the relative error (the ratio of the error to the target range) for the same target and sensor positions. Figure 10 shows the relative error as a function of target bearing for different sensor separation and velocity gradient conditions.

In examining the data it may be noted that there was no simple linear relationship which related the absolute error at one target range to another, thus interpolation is difficult. However, by plotting relative error versus target bearing, as in Figure 9b, it may be seen that the relative error was a linear function of target range.

As Figure 10 illustrates, when the sensors were on an isovelocity line, this relationship was found to be generally true for extreme sensor separations and target ranges also. However, for target ranges less than one-half the sensor separation and for target bearings less than 45° from the sensor axis the relationship did not hold. As was mentioned in section 4.3, the case when the target was less than one-half the sensor separation will be discussed in section 4.8. At target bearings less than 45° from the sensor axis there was less than a 10° difference between the target bearings from the two sensors, thus it is unlikely that a "fix" would be considered from these two bearings due to the large errors which would be induced by small differences in the measurement of either bearing. When the sensor axis was at 90° to the isovelocity line, the relative error was a linear function of target range for all target bearings, but as

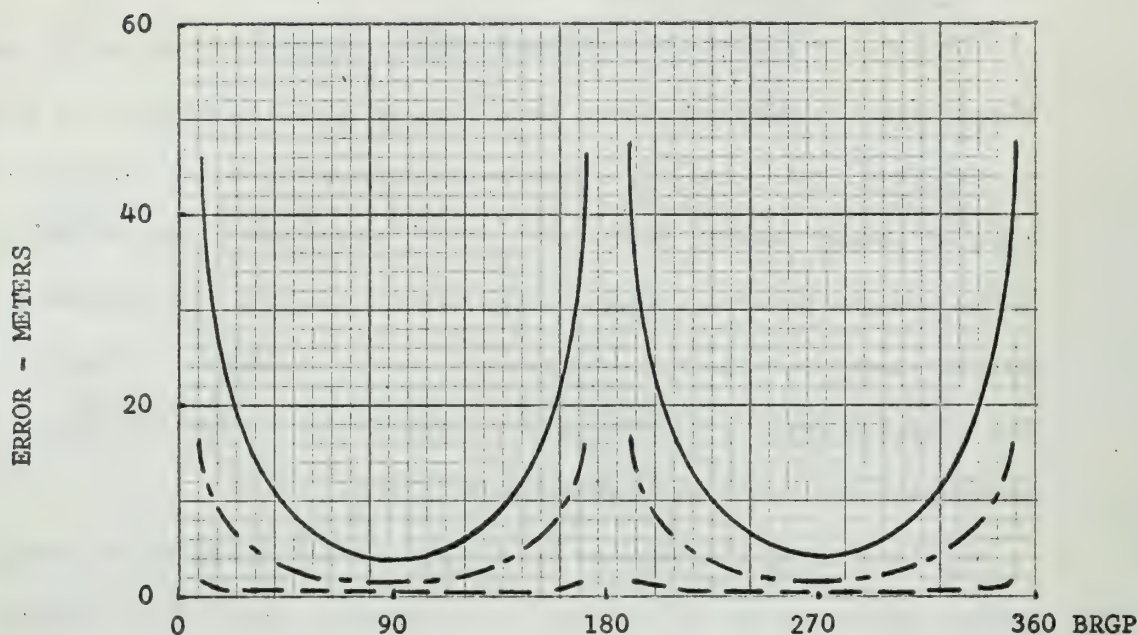


Figure 9a. Effect of Target Range on Absolute Error (Short Range)

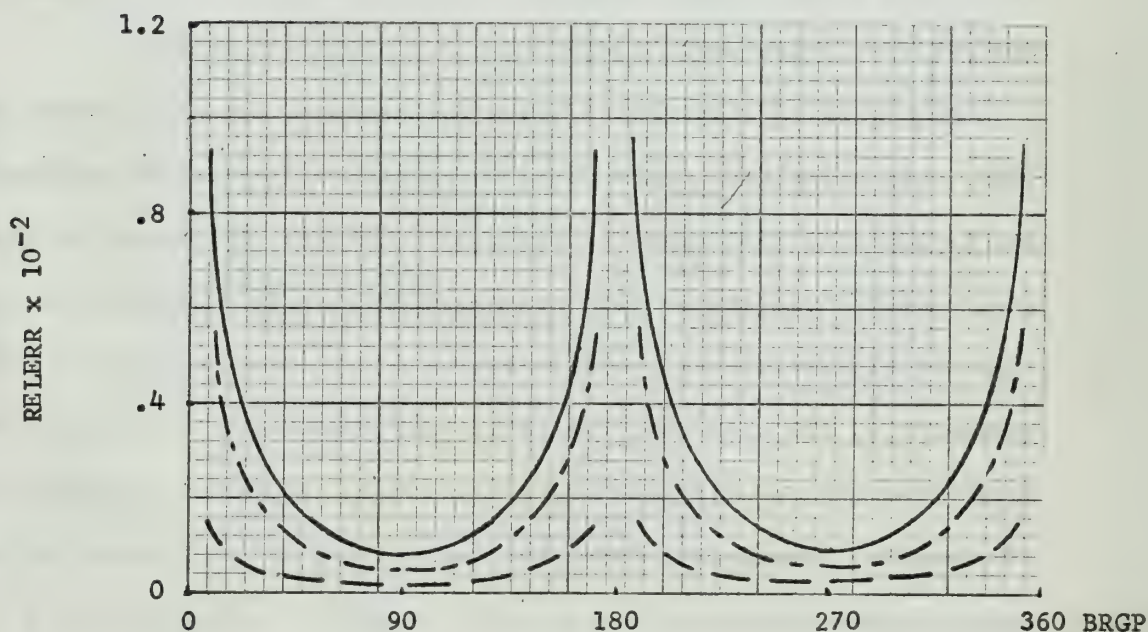


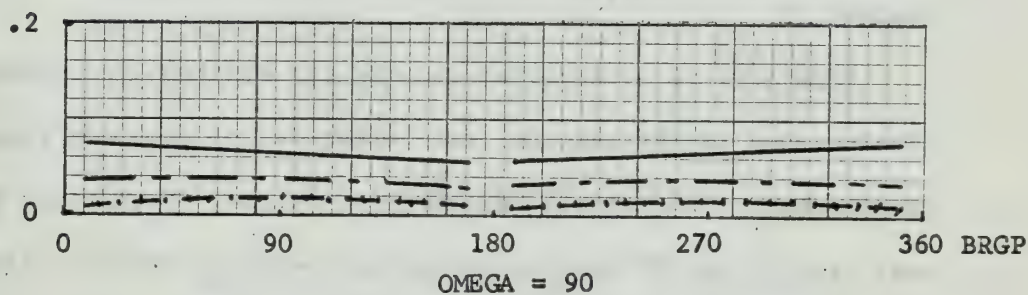
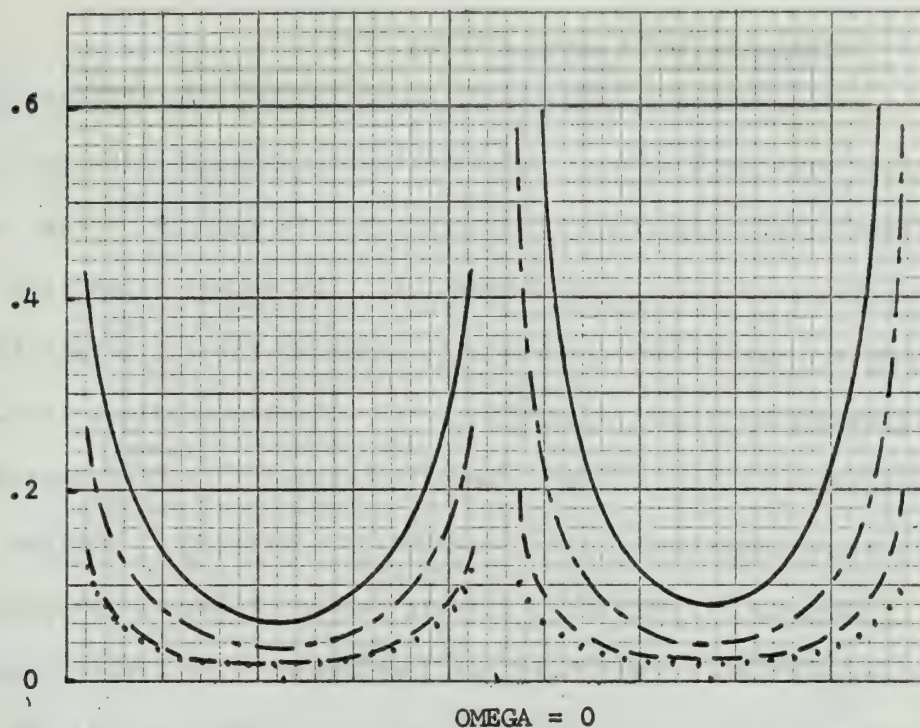
Figure 9b. Effect of Target Range on Relative Error (Short Range)

— RAPP = 5 km.
 - - - RAPP = 3 km.
 - . - RAPP = 1 km.

References:
 Tables 4, 9, 10

SS = 1 km., VGRAD = .0005, OMEGA = 0

RELERR



— RAPP = 2,000 km.
 - - - RAPP = 1,000 km.
 - . - RAPP = 500 km.
 . . . RAPP = 100 km.
 SS = 400 km., VGRAD = .0001

Reference:
Tables 8,11,12,13

Figure 10. Effect of Target Range on Relative Error (Long Range)

in the case when the sensor axis was along an isovelocity line, when the target range was less than one-half the sensor separation the linear relationship did not exist.

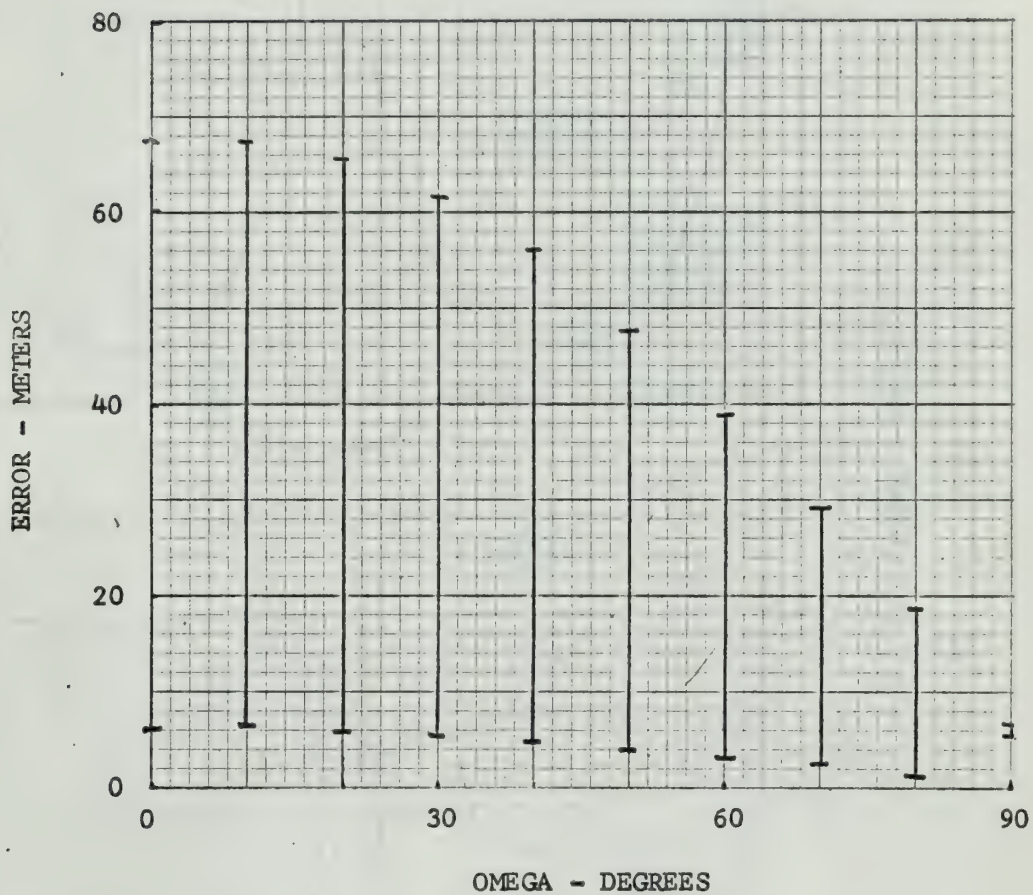
4.5 Effect of Sensor Axis Orientation.

As was noted in Figures 7, 8 and 10, the orientation (OMEGA) of the sensor axis with respect to the velocity gradient line had a very large effect on the magnitude of the errors. In general, errors were minimized when the sensor axis was aligned with the velocity gradient line. Further, the errors were practically constant for all target bearings when the sensor axis was aligned with the velocity gradient line. The only exceptions to this occurred when the target range was less than one-half the sensor separation and this case is discussed in section 4.8.

Figures 11, 12 and 13 illustrate the effect of rotation of the sensor axis from alignment with an isovelocity line (OMEGA equals 0°) to alignment with the velocity gradient line (OMEGA equals 90°). The data used to construct the graphs may be found in Tables 14 through 23 of Appendix III.

Figure 11 is a histogram showing the maximum and minimum errors, depending upon target bearing, for targets at an apparent range of 6 km. from sensors 2 km. apart. As the graph shows, by rotating the sensor axis from 0° to 90° the maximum errors were reduced by a factor of 10 to a value approximately equal to the minimum error. Figures 12a and 12b further illustrate the changes in the errors brought about by rotating the sensor axis.

Figure 13 depicts the actual and apparent target locations when the sensor axis was aligned with an isovelocity line and when the sensor axis was aligned with the velocity gradient line. It should be noted that the graph is not to an absolute scale, since on such a scale even the maximum

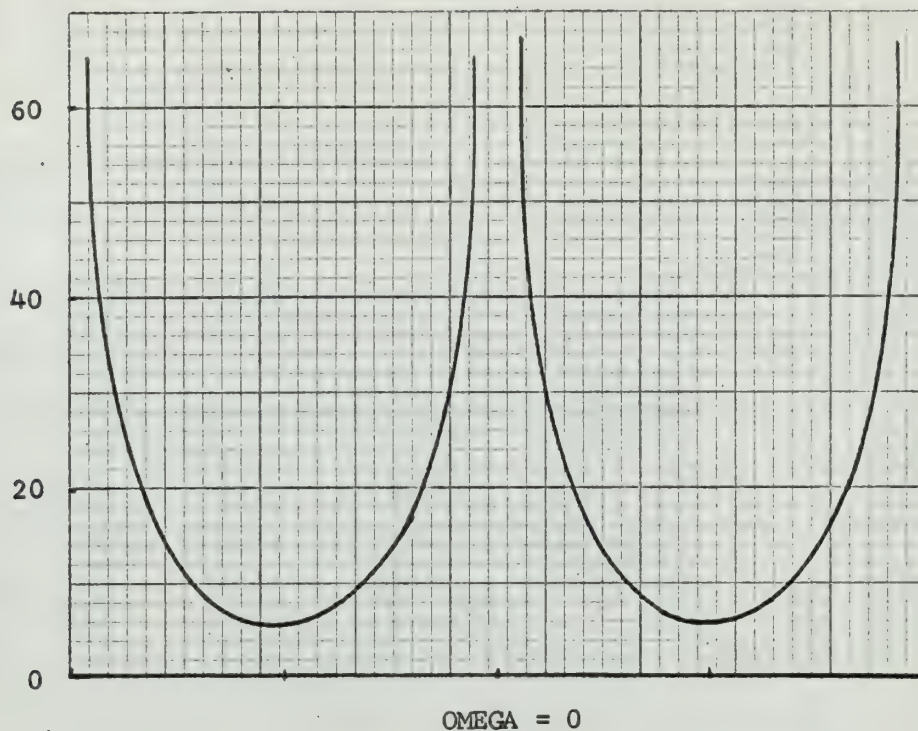


SS = 2 km., RAPP = 6 km.
VGRAD = .0005

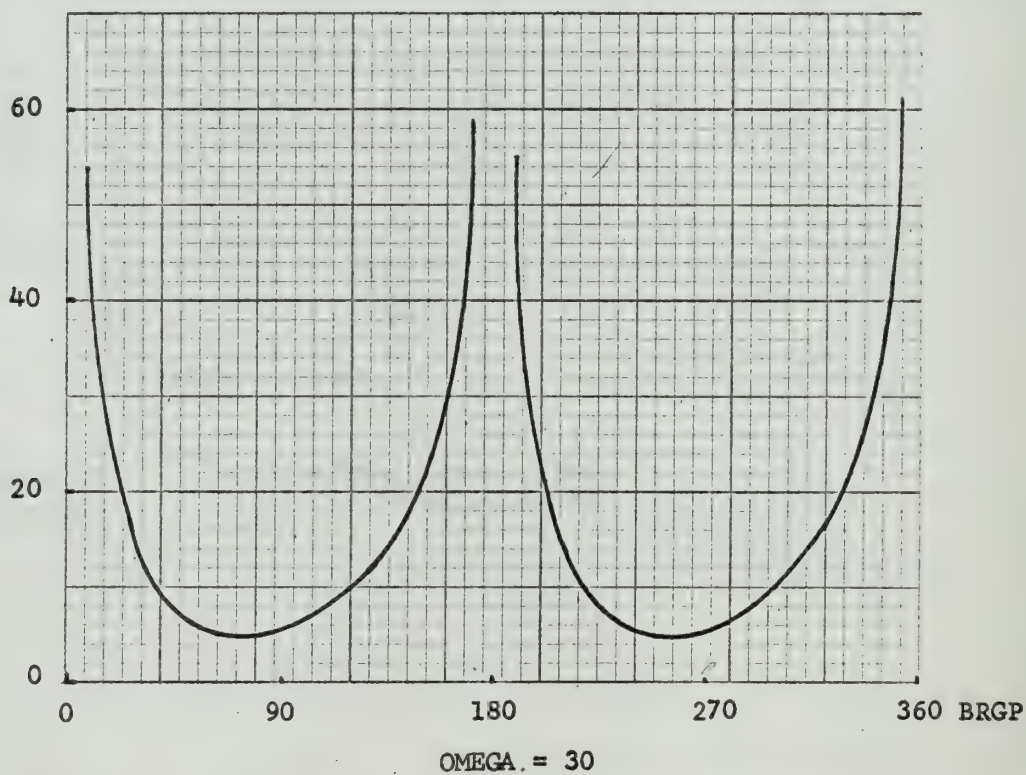
Reference:
Tables 14-23

Figure 11. Effect of Sensor Axis Orientation

ERROR - METERS



$\Omega = 0$



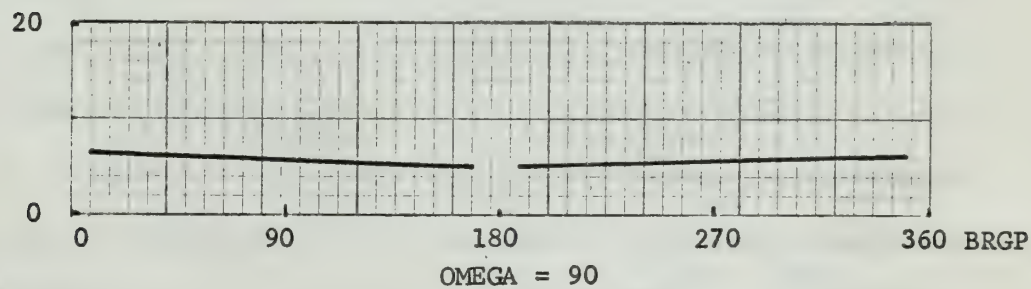
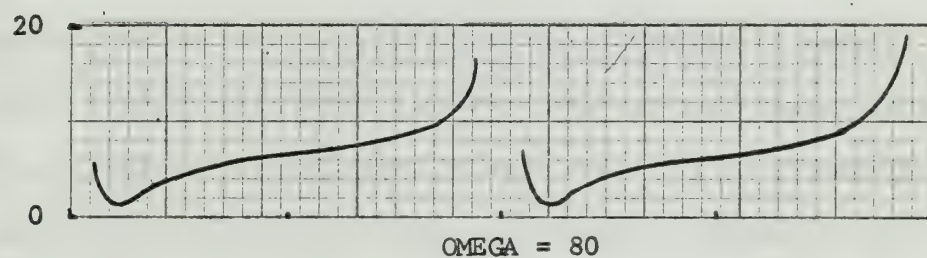
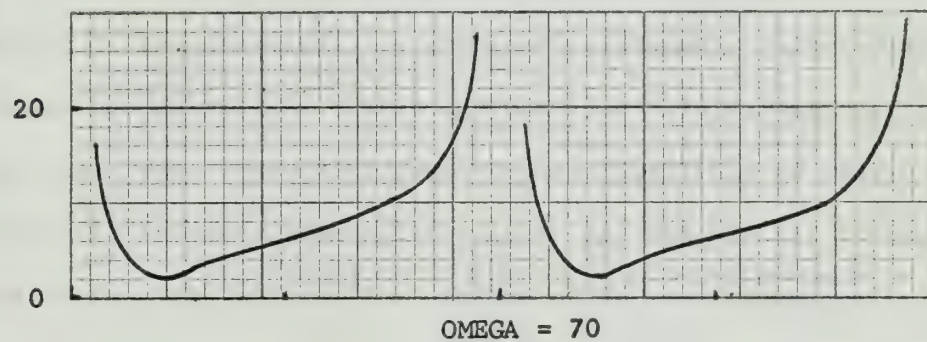
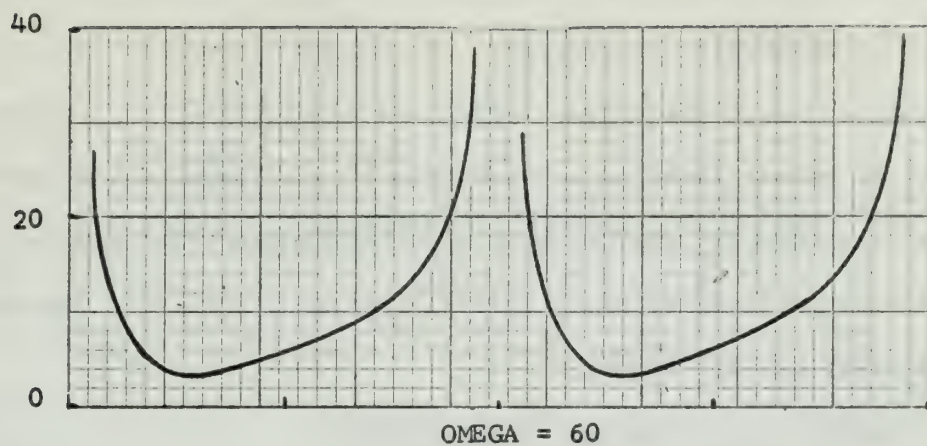
$\Omega = 30$

SS = 2 km., RAPP = 6 km.
VGRAD = .0005

Reference:
Tables 14-23

Figure 12a. Effect of Rotation of Sensor Axis

ERROR - METERS



SS = 2 km., RAPP = 6 km.
VGRAD = .0005

Reference:
Tables 14-23

Figure 12b. Effect of Rotation of Sensor Axis

error of 68 m. in 6000 m. could not be seen. However, the relative magnitudes of the errors are correct. As Figure 13 and the data in Tables 14 through 23 show, the actual target was closer than the apparent target when the sensors were in a lower velocity medium than the target and further away when the sensors were in a higher velocity medium. When the sensors were oriented along the velocity gradient line, however, this relationship was reversed.

4.6 Comparison at Constant Reduced Range.

Reduced range (REDRNG) was defined to be the ratio of the apparent target range to the sensor separation. This term was introduced to facilitate estimation of errors for any sensor separation and target range when the errors at a different sensor separation and target range are known. Figure 14 illustrates the linear relationship between relative errors at one sensor separation and those at another when compared at the same reduced range.

Figure 15 depicts relative error as a function of reduced range for various target bearings and a velocity gradient of .0005 m/sec per meter. As an example of the usefulness of such a plot, consider the following:

For a target located at a range of 5 km. on a 30° bearing from the midpoint of a line connecting two sensors 1 km. apart, Figure 15 shows a relative error of about .003 (REDRNG = 5., BRGP = 30). For a target located at a range of 500 km. on a 30° bearing from the midpoint of a line connecting two sensors 100 km. apart (at a reduced range of 5.) a predicted relative error would therefore be .3 (.003 times 100) for a gradient of .0005. Thus, using the fact (from section 4.2) that relative errors vary linearly with velocity gradient, for a gradient of .0001 a predicted relative error would be .06. The absolute error would then be estimated

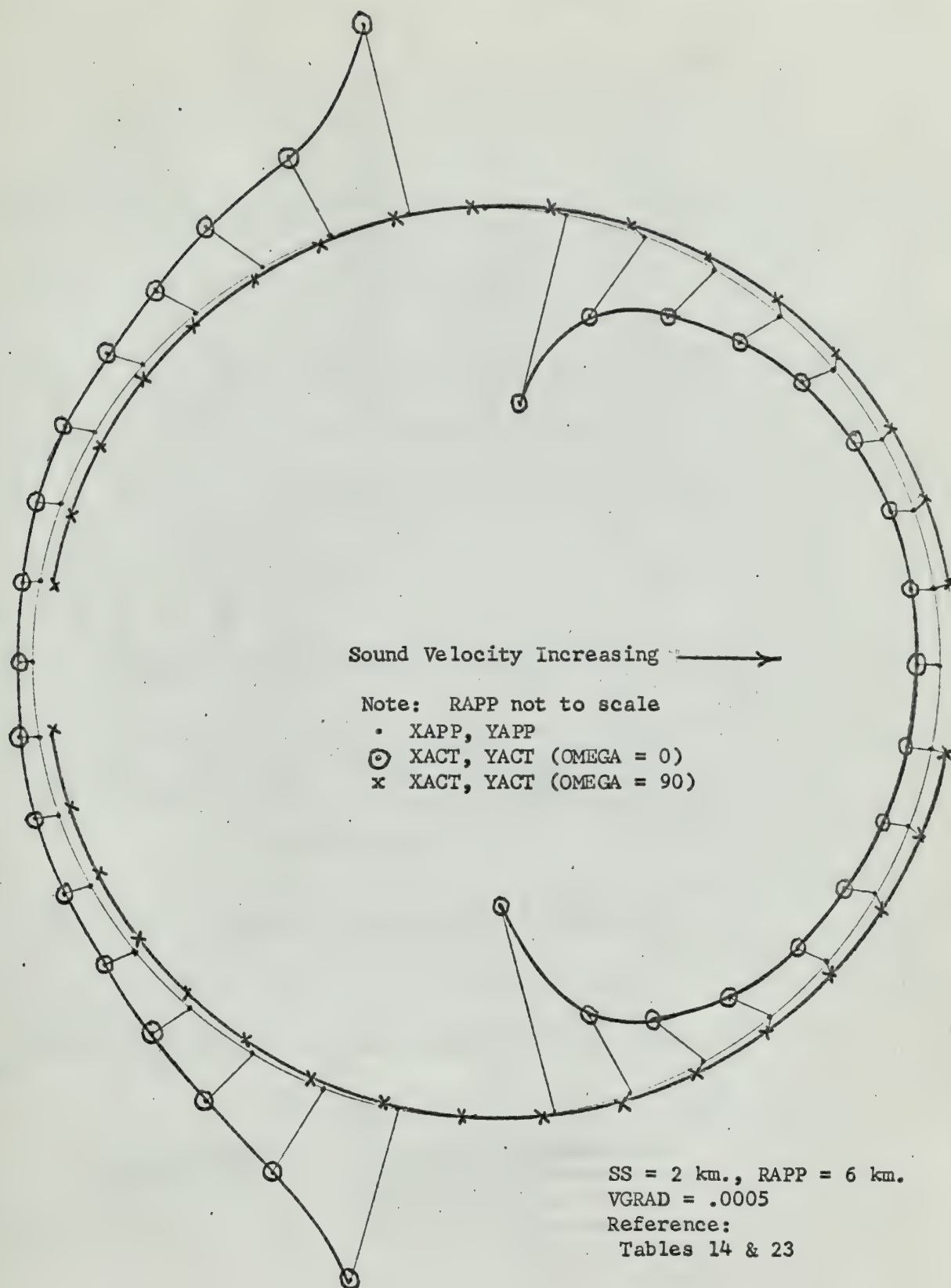


Figure 13. Actual Target Locations

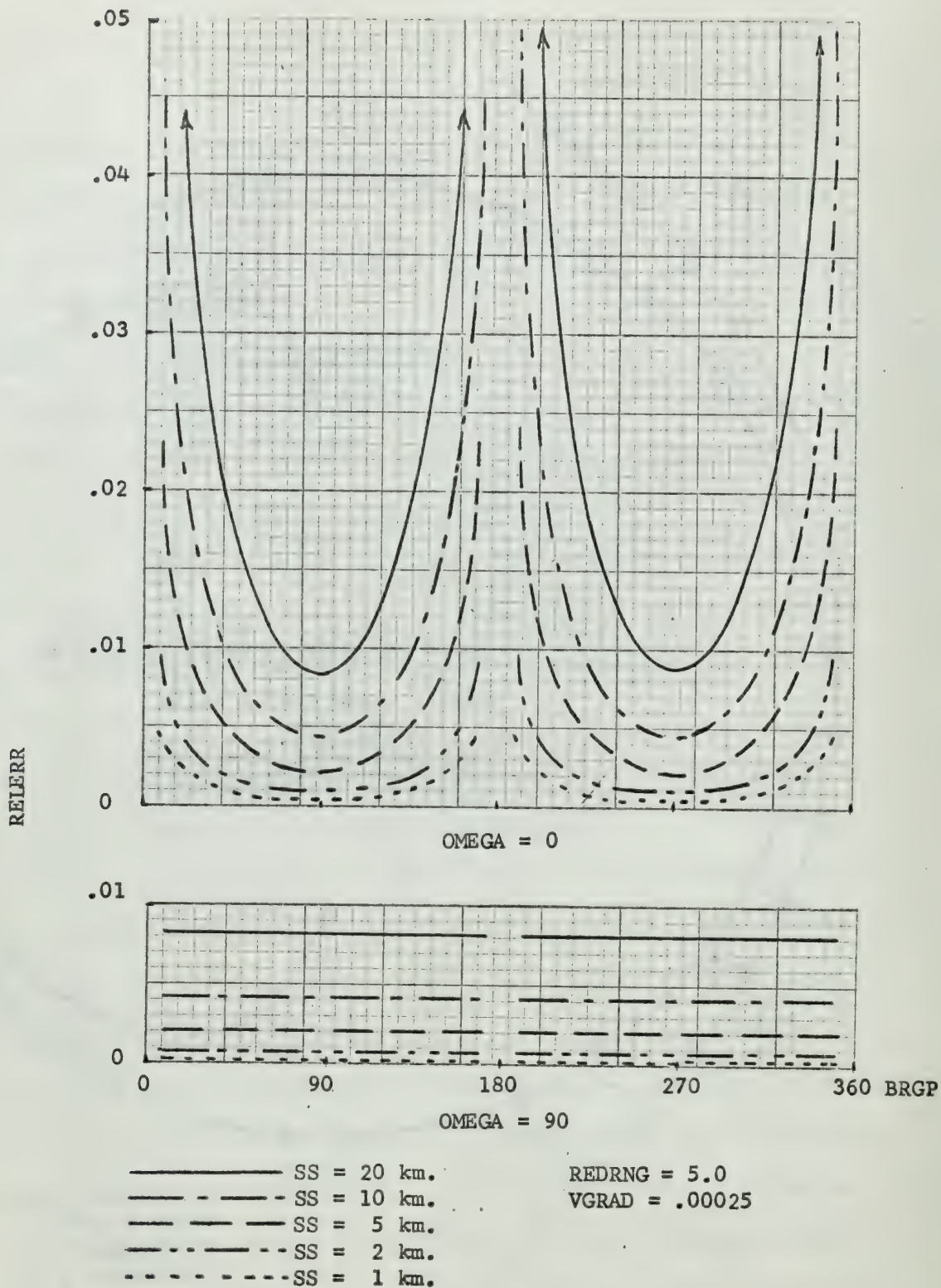


Figure 14. Effect of Sensor Separation at Constant Reduced Range

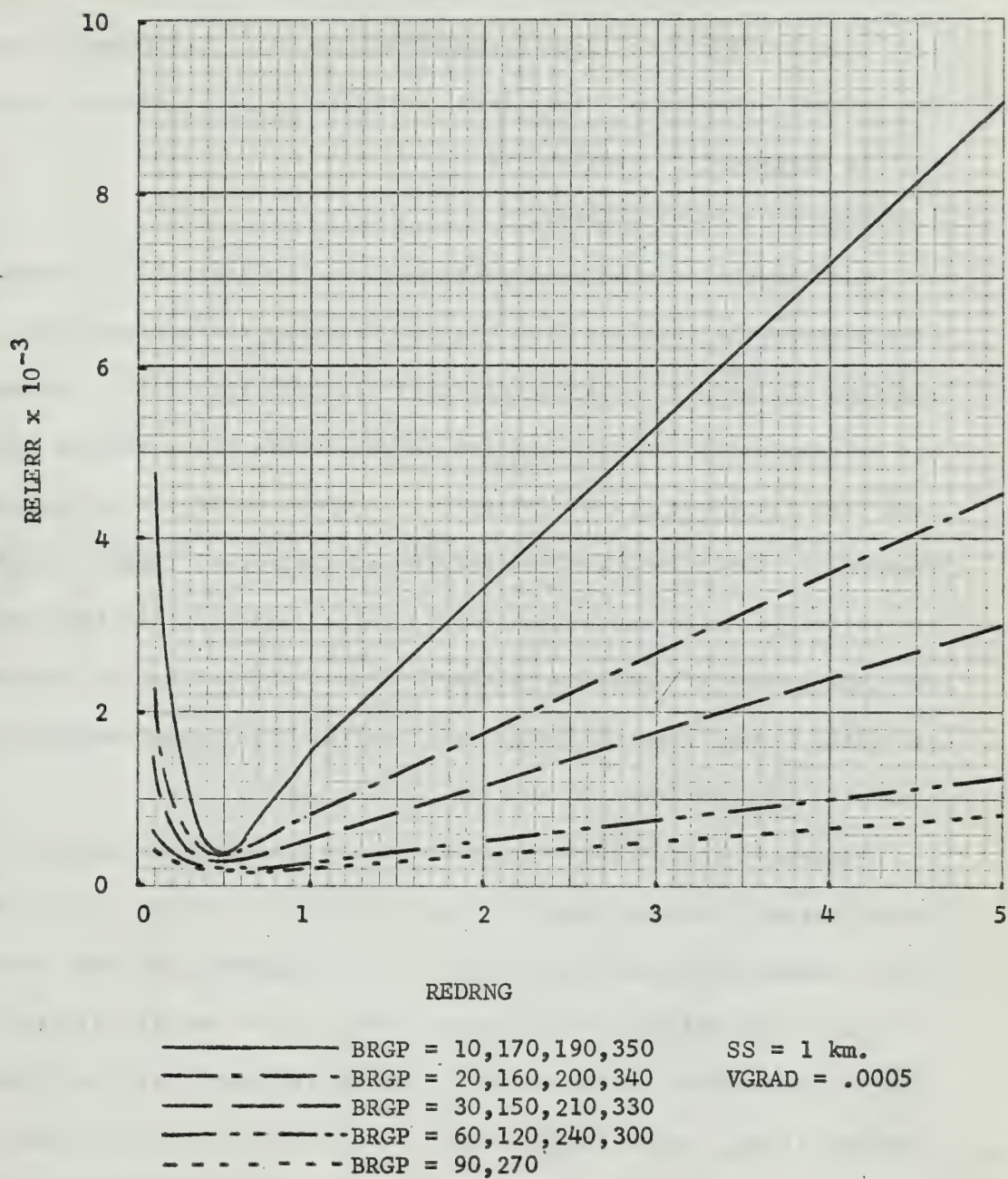


Figure 15. Relative Errors at Constant Reduced Range

to be 30 km. (.06 times 500). This compares favorably with the actual error of 28,151 m. found in Table 7 for this situation.

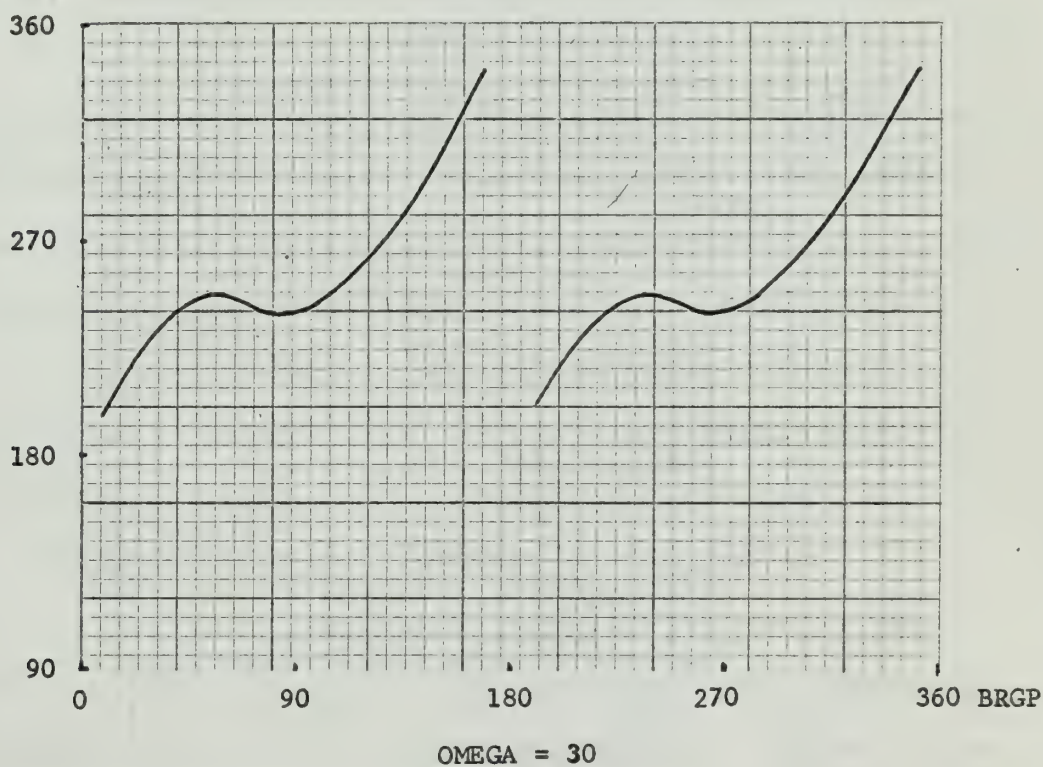
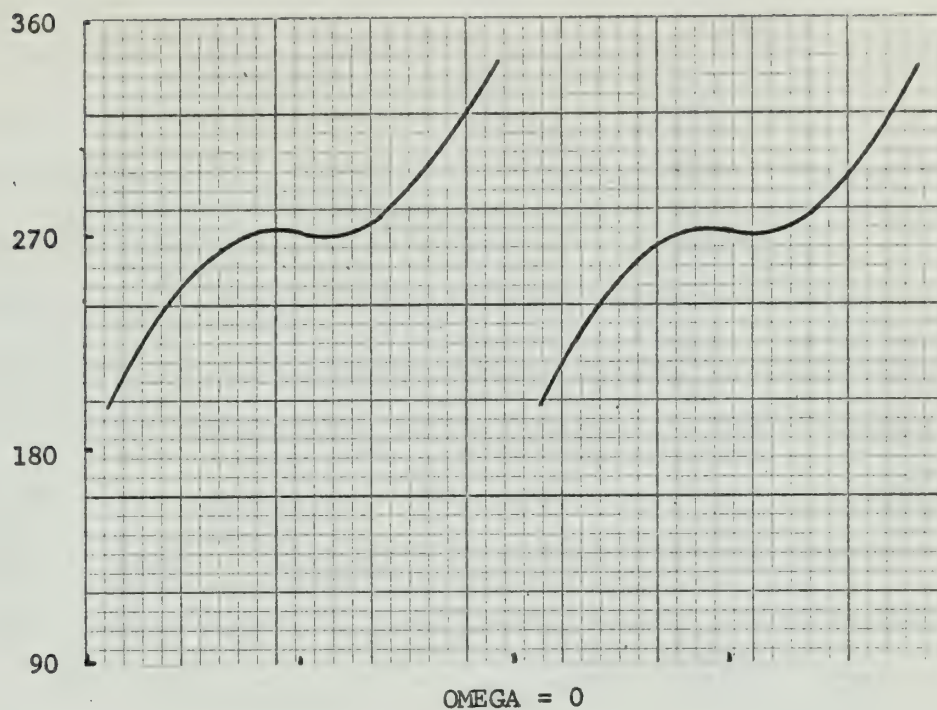
Over a wide range of sensor separations, target ranges and velocity gradients considered the error estimates obtained in this manner were always within 14% of the value computed by the model described in section 3. The unusual behavior of the curves in Figure 15 below reduced ranges of .5 will be discussed in section 4.8.

4.7 Effect on Bearing Error.

For targets located such that there was at least a 10° bearing difference between the bearings from the two sensors, the maximum error in bearing from the origin on the sensor axis was 2.2° (Table 13). Except for the extreme sensor separations and target ranges these bearing errors were less than 1, thus a graphic portrayal of these would not be meaningful. However, it was noted that the bearing of the actual target from the apparent target position was a function of target bearing from the origin and was independent of velocity gradient, sensor separation and apparent target range except when the range was less than the sensor separation. This case will be considered in section 4.8.

Figure 16 illustrates the relationship between the bearing of the actual target from the apparent target (BRGT) and the bearing of the apparent target from the origin (BRGP). Four figures have been drawn to illustrate the change in this relationship as the sensor axis was rotated from alignment with an isovelocity line to alignment with the velocity gradient line. As the figures show, the actual target was always toward the lower velocity medium from the apparent target position except for a sensor axis orientation along the velocity gradient line.

BRGT - DEGREES



SS = 400 km.
RAPP = 500 km.
VGRAD = .0001

Reference:
Tables 8, 24

Figure 16a. Target Bearing Corrections

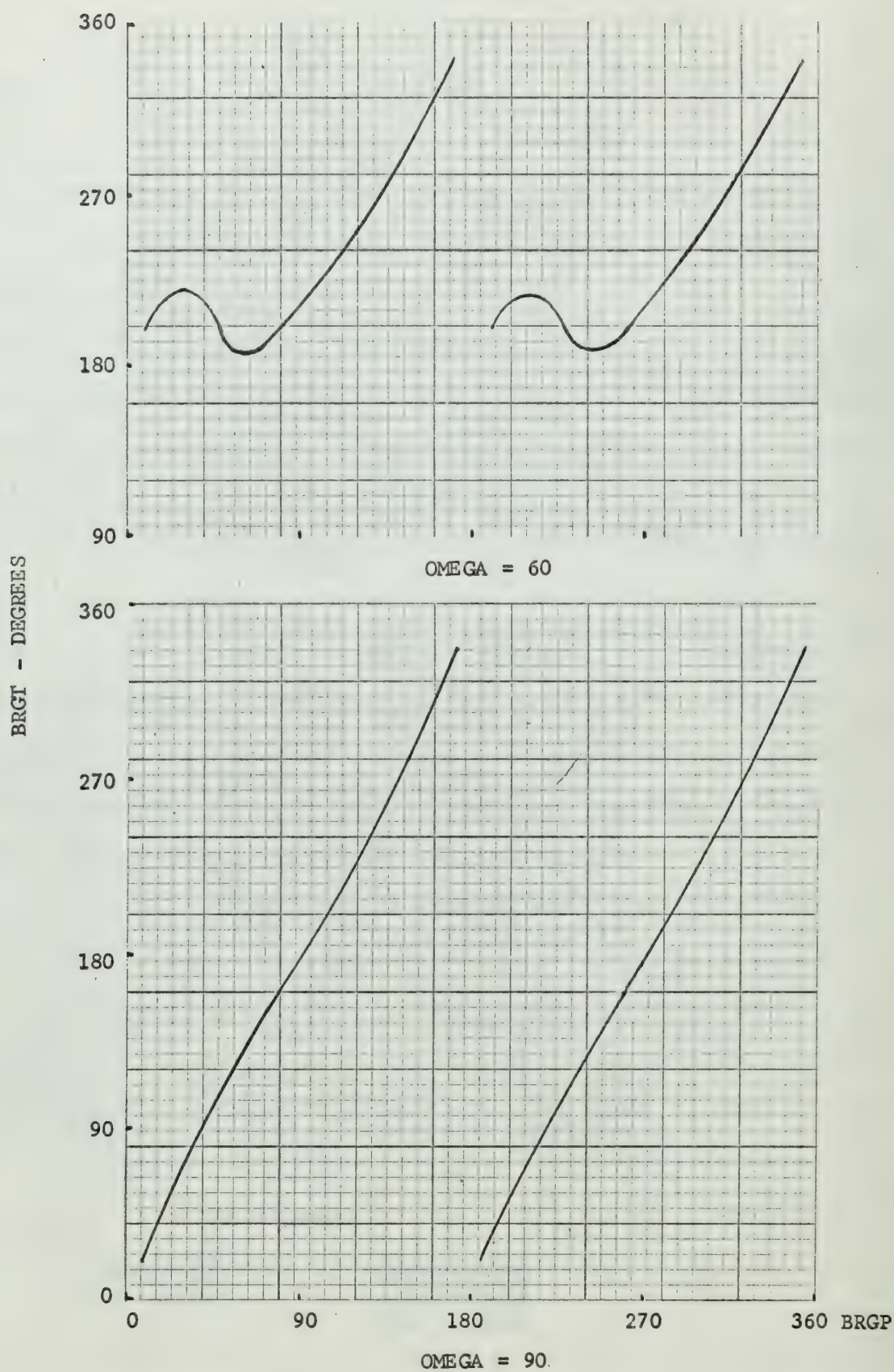


Figure 16b. Target Bearing Corrections

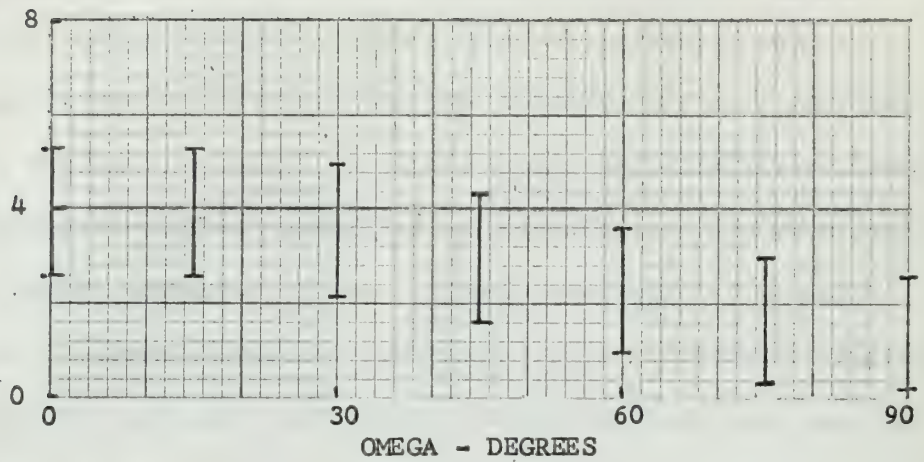
4.8 Effects When Target Range is Less Than Sensor Separation.

In the foregoing sections numerous references have been made to the fact that when the target range was less than the sensor separation, and particularly when the target range was less than one-half the sensor separation, many of the estimating relationships were no longer valid.

As may be seen from Figures 7 and 15, when the sensor axis was aligned with an isovelocity line, the effect of target bearing on the distance errors was the same for reduced range values less than 0.5 as it was for those above 0.5. However, when the sensor axis was rotated to alignment with the velocity gradient line, instead of the errors being almost constant the errors were greatest at those target bearings where they had been the least when the sensor axis was along an isovelocity line. This may be seen in Figure 7 and by a comparison of the data in Table 25 with that in Table 26.

Figures 17a and 17b illustrate the change in the absolute errors as the sensor axis was rotated. As may be seen in Figure 17a, the absolute errors decreased as the axis was rotated but when the reduced range equaled 0.5, the variation in error due to target bearing remained constant. This is contrasted with the behavior, as indicated by Figures 11 and 17b, of the error for values of reduced range both above and below 0.5 where the variation in the error as well as its absolute value decreased when the sensor axis was rotated to alignment with the velocity gradient line.

Figure 18 depicts absolute distance errors as a function of reduced range for reduced ranges from 0.1 to 1. As the figure shows, the maximum errors increased in value as the reduced range increased or decreased from a value of 0.5 when the sensor axis was along an isovelocity line but decreased uniformly as the reduced range decreased when the sensor axis was

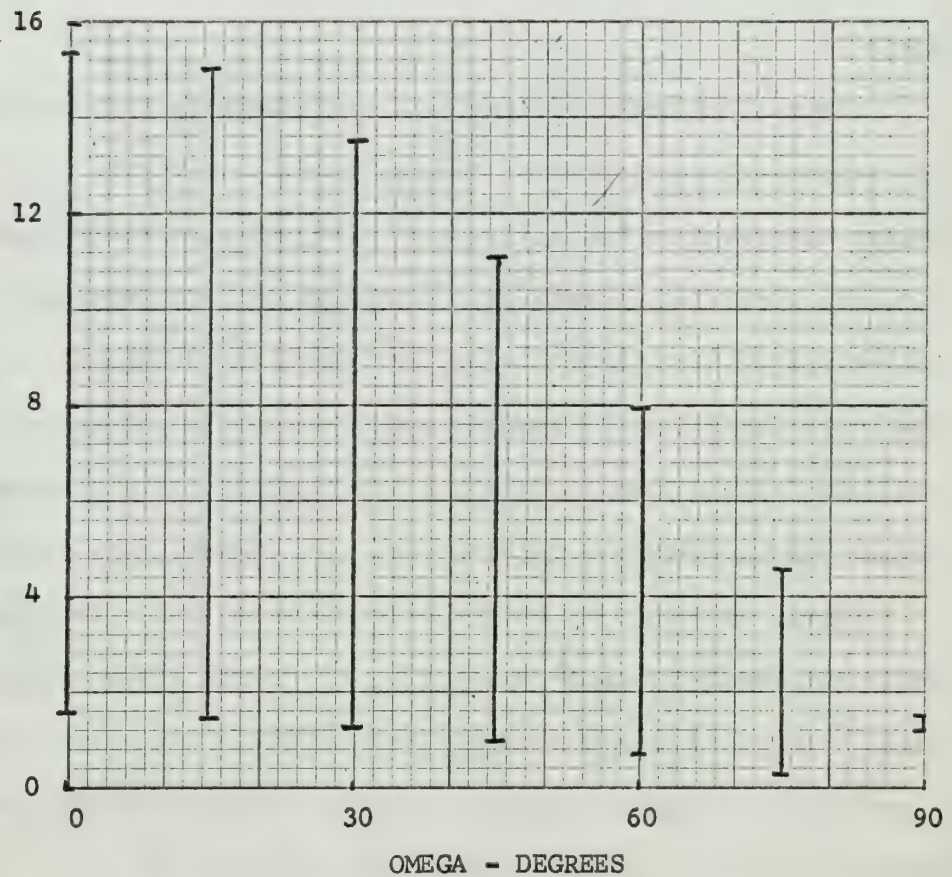


SS = 400 km., RAPP = 200 km.
VGRAD = .0001

Reference:
Tables 25,26

Figure 17a. Effect of Sensor Axis Orientation
(Reduced Range = .5)

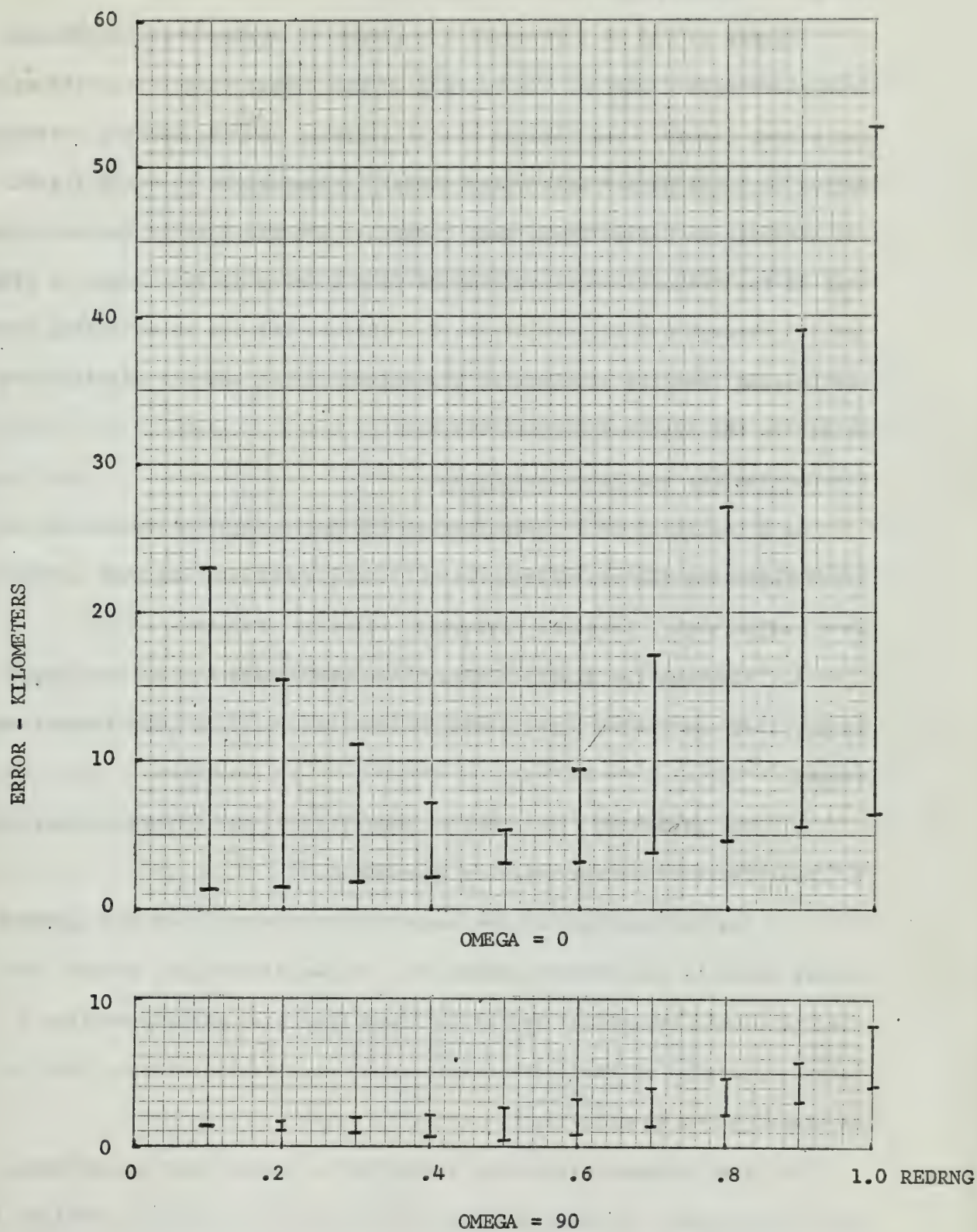
ERROR - KILOMETERS



SS = 400 km., RAPP = 80 km.
VGRAD = .0001

Reference:
Tables 27,28

Figure 17b. Effect of Sensor Axis Orientation
(Reduced Range = .2)



SS = 400 km.
VGRAD = .0001

Reference:
Tables 25, 26, 27, 28

Figure 18. Effects at Reduced Ranges Less Than 1.0

along the velocity gradient line.

Figures 19 and 20 illustrate the effect of apparent target bearing from the origin (BRGP) on the bearing of the actual target from the apparent target (BRGT). The figures also illustrate how the bearing correction varied with the sensor axis orientation. A comparison of these figures and the data in Tables 24-28 with Figure 16 and the data in Table 8 reveals that as the reduced range was lowered from a value greater than one (Figure 16) through 0.5 (Figure 17) to 0.3 (Figure 18) the relationship between the bearing from the apparent to the actual target and the bearing from the origin to the apparent target reversed.

5. Conclusions and Recommendations.

As a result of this investigation the following conclusions may be drawn regarding the crossfix errors of two directional acoustic sensors in a medium with a constant horizontal velocity gradient:

a. Although the distance errors are small relative to the target range, they can become appreciable in absolute value at very large target ranges.

b. For gradients within the values studied, the distance errors are a linear function of the velocity gradient.

c. The distance errors are sensitive to the ratio of the apparent target range to the sensor separation. If two directional sensors are used to obtain crossfixes and it is known from past experience that a large proportion of their detections occur at a certain range, they can be placed so as to minimize the crossfix error.

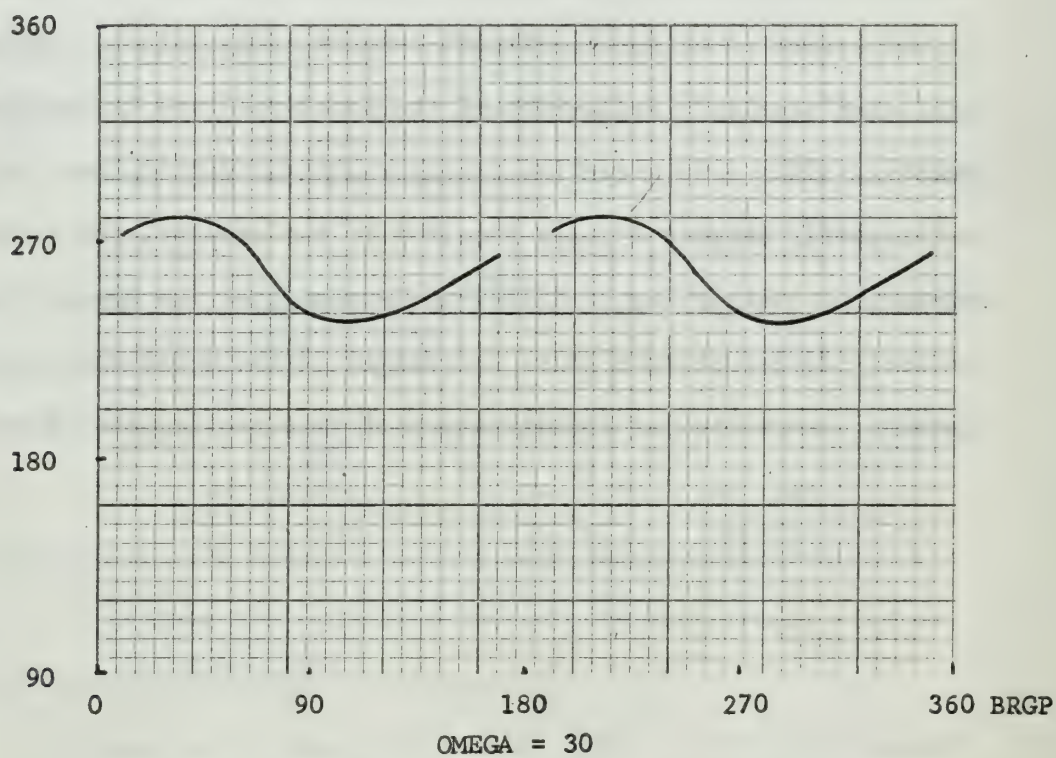
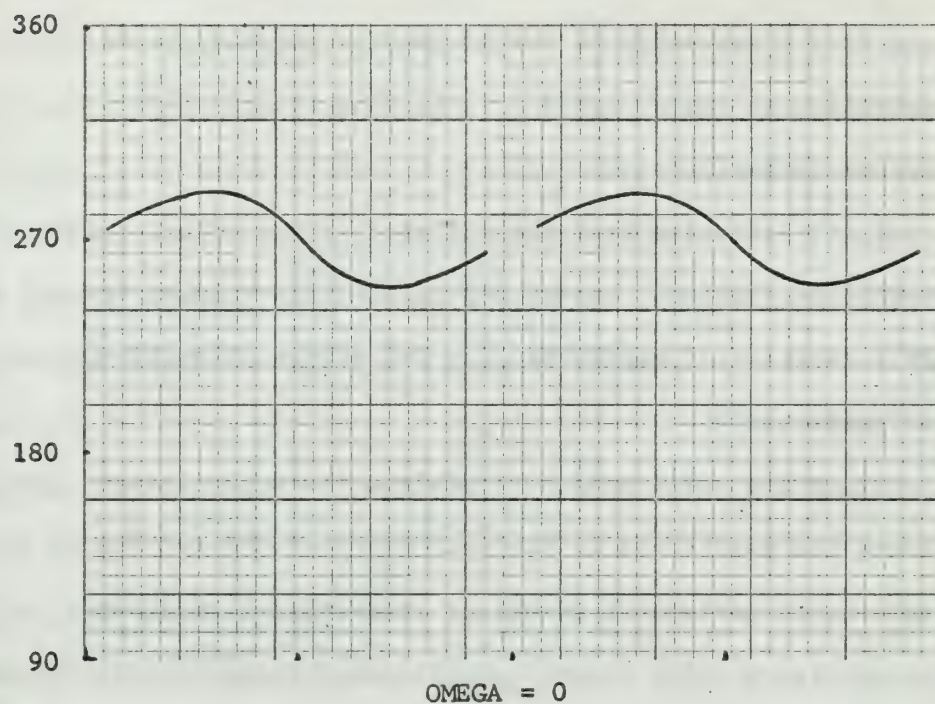
d. The distance errors are sensitive to target bearing and sensor axis orientation. By placing the sensors along the velocity gradient line, distance errors due to target bearing can be minimized.

e. The distance errors are predictable, i.e. the errors can be estimated from a knowledge of the horizontal velocity gradient, the sensor separation, the sensor axis orientation, the apparent target range and the apparent target bearing.

f. The bearing from the apparent to the actual target is independent of velocity gradient, sensor separation, and apparent target range. It is only a function of target bearing and sensor axis orientation, thus it is also predictable.

Since the model used to formulate these conclusions did not take into account the variations in the path of the sound ray due to vertical velocity gradients or horizontal gradients other than linear ones, the investigation of errors using a more sophisticated three-dimensional model is recommended. Such an investigation should, of course, determine the sensitivity of the errors to bottom conditions such as slope, since a sloping bottom will also result in deflection of the sound ray from its original course. Further, since some directional sensor systems depend upon the time phase relationship between a pulse received by two sensors, the errors caused by the actual paths being of different lengths than the apparent paths may be entirely different from those calculated by the model used in this investigation. Therefore, an investigation of this problem should be considered.

BRGT - DEGREES



SS = 400 km.
RAPP = 200 km.
VGRAD = .0001

Reference:
Table 25

Figure 19a. Target Bearing Corrections
(Reduced Range = .5)

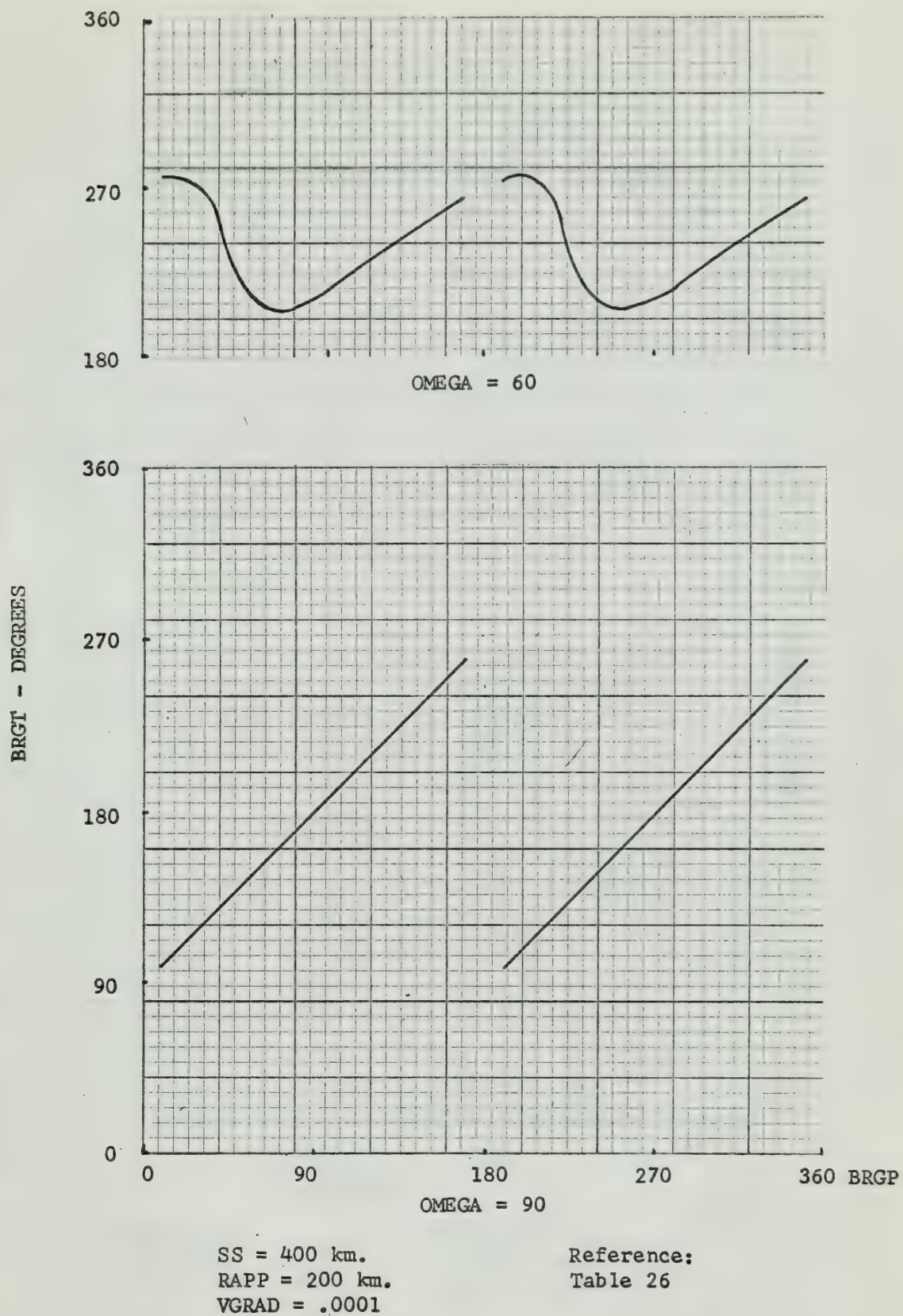
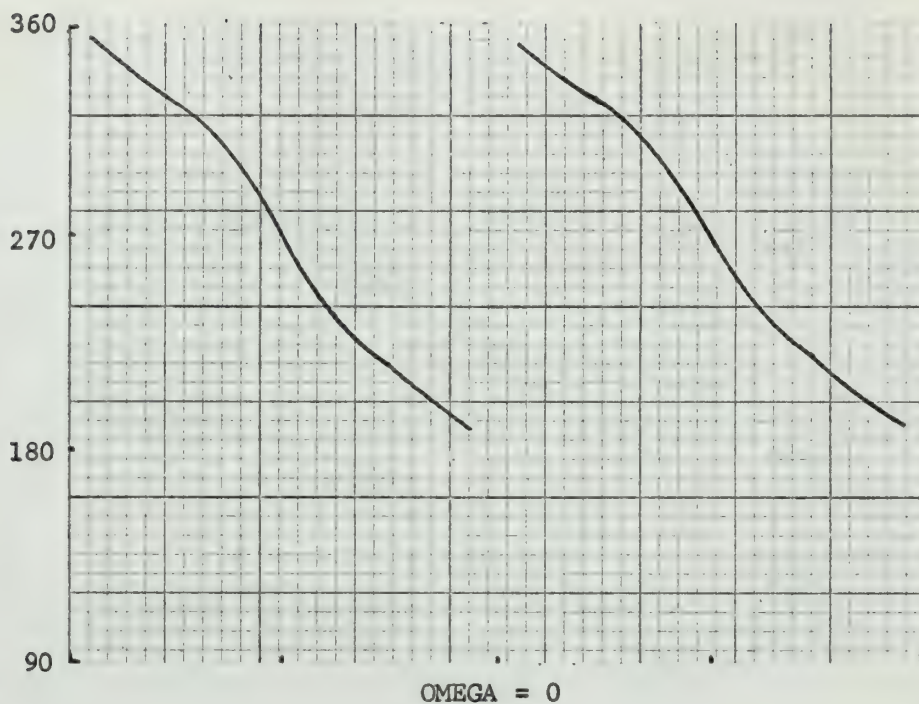
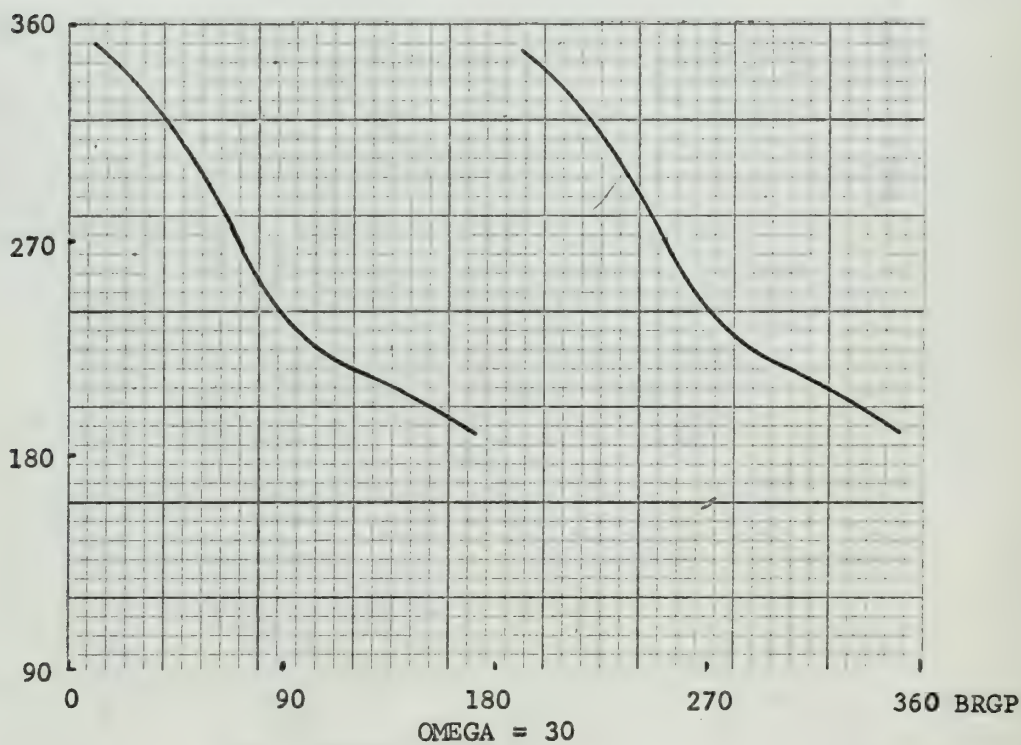


Figure 19b. Target Bearing Corrections
(Reduced Range = .5)



BRGT - DEGREES

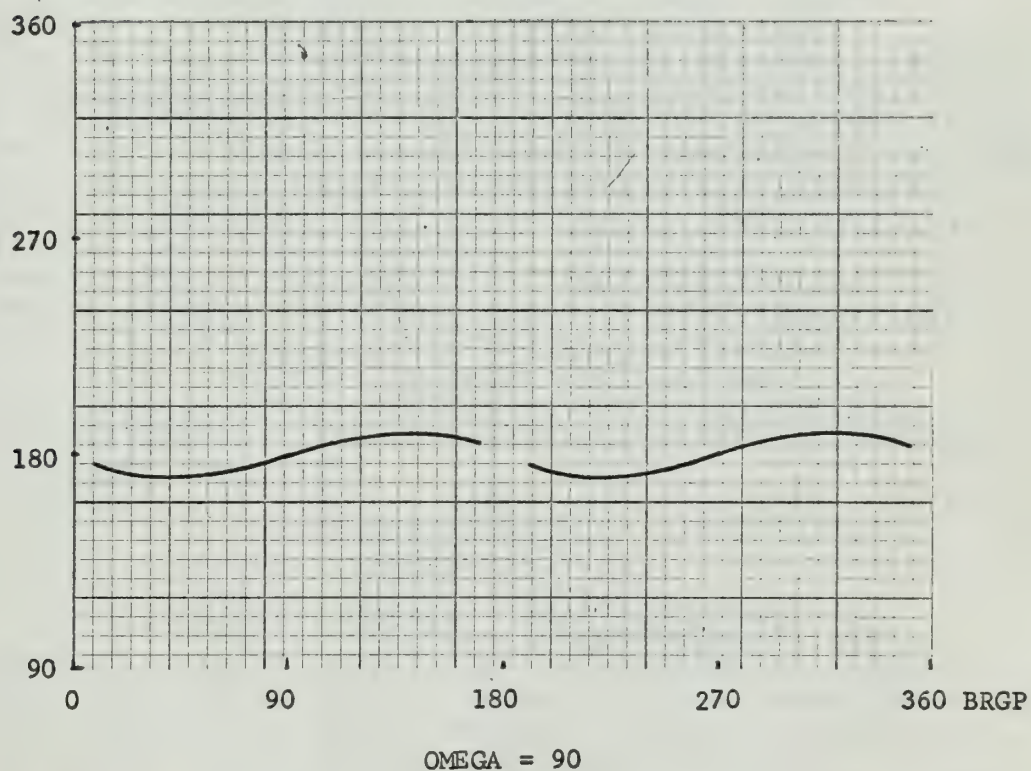
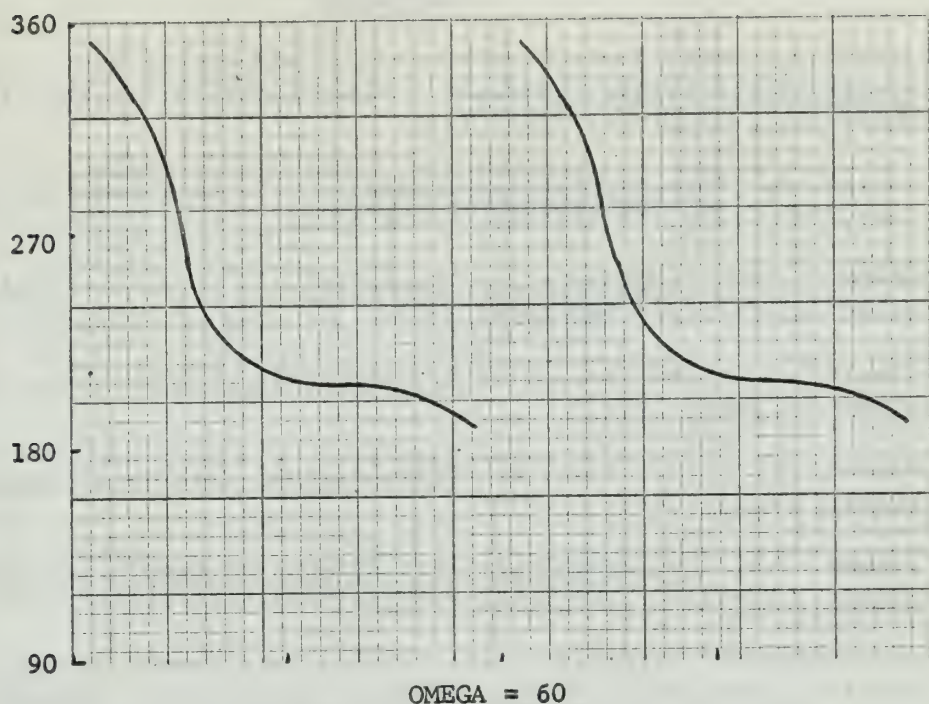


SS = 400 km.
RAPP = 80 km.
VGRAD = .0001

Reference:
Table 27

Figure 20a. Target Bearing Corrections
(Reduced Range = .2)

BRGT - DEGREES



SS = 400 km.
RAPP = 80 km.
VGRAD = .0001

Reference:
Table 28

Figure 20b. Target Bearing Corrections
(Reduced Range = .2)

BIBLIOGRAPHY

1. Ayres, E.; Woff, P.M.; Carstenson, L.; and Ayres, H.C. A Ray Tracing Program for a Digital Computer. Fleet Numerical Weather Facility, Monterey, California. June 1966.
2. Halley, R. Physics of Passive Sonar. U.S. Navy Electronics Laboratory, San Diego, California. June 1962.
3. Horton, J.W. Fundamentals of Sonar Vol. 1. U.S. Navy Underwater Sound Laboratory. September 1950.
4. Kinsler, L.E. and Frey, A.R. Fundamentals of Acoustics, 2nd ed. John Wiley and Sons, 1962.
5. Newmann, G. and Pierson, W. Principles of Physical Oceanography. Prentice-Hall, 1966.
6. Pigman, J.W. Horizontal Gradient Effects on Directional Acoustic Sensors. Thesis, U.S. Naval Postgraduate School, May 1966.
7. U.S. Office of Scientific Research and Development, National Defense Research Committee. Physics of Sound in the Sea. Research Analysis Group, Committee on Undersea Warfare, National Research Council, 1951.

APPENDIX I

-COOP,,A DORSEY, S/1S/2S,3,5000,2.

-FTN,L,E.

PROGRAM HRZGRD1

C THIS IS A PROGRAM TO COMPUTE THE BEARING AND DISTANCE
 C ERRORS IN A SONAR FIX WHICH RESULT FROM HORIZONTAL
 C TEMPERATURE GRADIENTS IN THE WATER.
 C THIS PROGRAM IS WRITTEN IN FTN-63 FOR A CDC 1604 COMPUTER.
 C THE Y AXIS IS AN ISOVELOCITY LINE WHERE THE VELOCITY IS V0.
 C THE ORIGIN (X=0,Y=0) IS A POINT MIDWAY BETWEEN THE TWO
 C SENSORS AND IS THE INTERSECTION OF THE Y AXIS AND A LINE
 C THROUGH THE TWO SENSORS.
 C SENSOR A IS LOCATED AT X1,Y1 AND SENSOR B IS AT XX1,YY1.
 C ALL BEARINGS WITH THE PREFIX BRG ARE RELATIVE TO AN AXIS
 C THROUGH THE TWO SENSORS.
 C ALL BEARINGS DESIGNATED BY GREEK LETTERS ARE RELATIVE TO
 C THE Y AXIS.
 C ALL RANGES AND DISTANCES ARE IN METERS.
 C ANGLES IS A SUBROUTINE TO CALCULATE ANGLES FROM 0 TO 360
 C DEGREES USING TANGENTS.
 C BRGA IS THE BEARING FROM A TO THE APPARENT TARGET.
 C BRGB IS THE BEARING FROM B TO THE APPARENT TARGET.
 C BRGG IS THE BEARING FROM THE ORIGIN TO THE ACTUAL TARGET.
 C BRGP IS THE BEARING FROM THE ORIGIN TO THE APPARENT TARGET.
 C BRGT IS THE BEARING FROM THE APPARENT TO THE ACTUAL TARGET.
 C ERROR IS THE DISTANCE BETWEEN APPARENT AND ACTUAL POSITION.
 C RACT IS THE ACTUAL RANGE OF THE TARGET FROM THE ORIGIN.
 C RAPP IS THE APPARENT RANGE OF THE TARGET FROM THE ORIGIN.
 C RAPPINC IS THE RANGE INCREMENT.
 C RAPPMAX IS THE MAXIMUM APPARENT RANGE CONSIDERED.
 C REDRNG IS APPARENT RANGE DIVIDED BY SENSOR SEPARATION.
 C RELERR IS THE RELATIVE DISTANCE ERROR (ERROR/RAPP).
 C RNGERR IS THE DIFFERENCE BETWEEN RACT AND RAPP.
 C RPD CONVERTS ANGLES IN DEGREES TO ANGLES IN RADIANS.
 C (RADIANS=DEGREES TIMES .01745329252 RADIANS PER DEGREE)
 C SS IS SENSOR SEPARATION.
 C V0 IS THE VELOCITY AT X=0, VGRAD IS THE VELOCITY GRADIENT.
 C XACT,YACT IS ACTUAL TARGET POSITION.
 C XAPP,YAPP IS APPARENT TARGET POSITION.
 C XINC IS THE DISTANCE INCREMENT IN THE X DIRECTION.
 C YDIFF IS THE DESIRED PRECISION IN CLOSENESS OF THE
 C COMPUTED AND ACTUAL POINTS OF INTERSECTION OF TWO RAYS.
 C ALPHA IS THE BEARING OF THE APPARENT TARGET FROM SENSOR A.
 C BETA IS THE BEARING OF THE APPARENT TARGET FROM SENSOR B.
 C DELTA IS THE DIFFERENCE BETWEEN GAMMA AND PHI.
 C GAMMA IS THE BEARING FROM THE ORIGIN TO THE ACTUAL TARGET.
 C OMEGA IS THE ANGLE BETWEEN THE Y AXIS AND A LINE THROUGH
 C THE TWO SENSORS. IT CAN VARY FROM 0 TO +90 DEGREES.
 C PHI IS THE BEARING FROM THE ORIGIN TO THE APPARENT TARGET.
 C PI IS 3.1415926536
 C TAU IS THE BEARING FROM THE APPARENT TO THE ACTUAL TARGET.

APPENDIX I

```

C
C READ IN DATA.
C
I 100 RPD = .01745329252      $ PI=3.1415926536
  110 READ 111, VO,VGRAD,YDIFF
  111 FORMAT(3F10.0)
II 120 READ 121, SS,RAPP,RAPPMAX,RAPPINC,XINC
  121 FORMAT (5F10.0)
III 130 PROGRAM STOPS WHEN SENSOR SEPARATION IS NEGATIVE.
  122 IF (SS) 900,900,125
  125 OMEGA=0.0
IV 132 OMEGAR=OMEGA*RPD
  140 Y1=SS/2*COSF(OMEGAR)      $ YY1=-Y1
  141 X1=SS/2*SINF(OMEGAR)      $ XX1=-X1
  170 REDRNG=RAPP/SS
  183 PRINT 184,OMEGA,SS,RAPP,REDRNG,VO,VGRAD,YDIFF
  184 FORMAT(1H1,16(/),5X,8HOMEGA = F3.0,9X,5HSS = F6.0,9X,
V    17HRAPP = F7.0,9X,9HREDRNG = F4.3,15X,5HVO = F6.1,
    212X,8HVGRAD = F7.5,12X,8HYDIFF = F3.1,15X)
  185 PRINT 186
  186 FORMAT(2X,4HBRGP4X,4HRACT6X,2HV26X,4HBRGA4X,4HBRGB5X,
    15HERROR4X,4HBRTGT3X,5HDELTA3X,6HRNGERR3X,6HRELERR)
C
  200 DO 600 I=1,35
  201 IF(I-18) 205,520,205
C ROUTINE TO SET APPARENT TARGET POSITION
  205 BRGP = 10.*I
  206 ICOUNT=0
  210 PHI=OMEGA+BRGP
C TEST TO ENSURE THAT PHI IS LESS THAN 360 DEG.
  211 IF(PHI-360.) 213,213,212
  212 PHI=PHI-360.
VI C ROUTINE TO COMPUTE RELATIVE BEARING OF TARGET FROM SENSORS
  213 PHIR=PHI*RPD
  214 XAPP=RAPP*SINF(PHIR)      $ YAPP=RAPP*COSF(PHIR)
  220 K=1 $ CALL ANGLES(X1,Y1,XAPP,YAPP,ALPHA,K)
  221 ALPHAR=ALPHA*RPD          $ BRGA=ALPHA-OMEGA
  222 IF(BRGA) 223,225,225
  223 BRGA=BRGA+360.
  225 K=2 $ CALL ANGLES(XX1,YY1,XAPP,YAPP,BETA,K)
  226 BETAR=BETA*RPD           $ BRGB=BETA-OMEGA
  227 IF(BRGB) 228,230,230
  228 BRGB=BRGB+360.
C
C ROUTINE TO TRACE RAYS AND COMPUTE ACTUAL TARGET POSITION
VII C
  230 XA=X1 $ YA=Y1      $ XB=XX1 $ YB=YY1
  231 IF(OMEGA) 232,299,232
  232 VA=VO+VGRAD*X1      $ VB=VO+VGRAD*XX1
  233 ALPHAR1=ALPHAR      $ BETAR1=BETAR
VIII C TEST TO SEE IF X1 IS LESS THAN XAPP IN ABSOLUTE VALUE
  233 IF(ABSF(XAPP)-ABSF(X1)) 240,280,280
C

```

APPENDIX I

```

C ROUTINE TO COMPUTE XACT,YACT WHEN X1 IS GREATER THAN XAPP
C IN ABSOLUTE VALUE.
IX 240 RATIOA=COSF(ALPHAR1)/VA      $ RATIOB=COSF(BETAR1)/VB
    X2=XX1      $ XXINC=XINC
    241 X2=X2+XXINC      $ V2=V0+VGRAD*X2
        IF(ABSF(V2*RATIOA).GT.1.) 257,242
    242 IF(ABSF(V2*RATIOB).GT.1.) 257,243
    243 ALPHAR2=2.*PI-ACOSF(V2*RATIOA)
        BETAR2=ACOSF(V2*RATIOB)
        DXA=XA-X2      $ DXB=X2-XB
C NOTE SIGN OF DXA IS ALWAYS +.
    DYA=DXA/TANF((ALPHAR1+ALPHAR2)/2.)
    DYB=DXB/TANF((BETAR1+BETAR2)/2.)
    Y2A=YA-DYA      $ Y2B=YB+DYB
C TEST FOR INTERSECTION OF RAYS
C CHECK TO SEE IF CRITICAL ANGLE LIMITED.
    ICOUNT=ICOUNT+1      $ IF(ICOUNT.LT.200) 244,530
    244 IF(180.-BRGA) 245,520,255
    245 IF(Y2A-Y2B) 246,258,241
    246 IF((Y2B-Y2A).LT.YDIFF) 258,257
    255 IF(Y2B-Y2A) 256,258,241
    256 IF((Y2A-Y2B).LT.YDIFF) 258,257
    257 X2=X2-XXINC      $ XXINC=.1*XXINC      $ GO TO 241
    258 XACT=X2      $ YACT=Y2A      $ GO TO 400
X  AC
C ROUTINE TO GET XB EQUAL TO XA WHEN ABSOLUTE VALUE OF X1 IS
C LESS THAN ABSOLUTE VALUE OF XAPP
    280 IF(PHI-180.)281,281,291
X  AC
C CALCULATION OF STARTING POINTS OF RAYS WHEN PHI IS LT. 180
XI 281 DX=XA-XB
    BETAR1=ACOSF(VA*COSF(BETAR)/VB)
    DY=DX/TANF((BETAR+BETAR1)/2.)
    285 YB=YB+DY      $ XB=XA      $ V1=V0+VGRAD*XA
        ALPHA1=ALPHA      $ BETA1=BETAR1/RPD
C AT THIS POINT BOTH RAYS HAVE THE SAME X COORDINATE.
    286 GO TO 300
X  AC
C CALCULATION OF STARTING POINTS OF RAYS WHEN PHI IS GT. 180
    291 DX=XA-XB
C NOTE THAT SIGN OF DX IS ALWAYS +.
    ALPHAR1=2.*PI-ACOSF(VB*COSF(ALPHAR)/VA)
    DY=DX/TANF((ALPHAR+ALPHAR1)/2.)
XII 295 YA=YA-DY      $ XA=XB      $ V1=V0+VGRAD*XB
        ALPHA1=ALPHAR1/RPD      $ BETA1=BETA
C AT THIS POINT BOTH RAYS HAVE THE SAME X COORDINATE.
    296 GO TO 300
X  AC
XIII 299 V1=V0      $ ALPHAR1=ALPHAR      $ BETAR1=BETAR
        VA=V0+VGRAD*X1      $ VB=V0+VGRAD*XX1
        ALPHA1=ALPHA      $ BETA1=BETA
C
C AT THIS POINT THE RAYS ARE DISTANCE STEPPED IN THE + OR -X
C DIRECTION (DEPENDING UPON PHI) UNTIL THEY INTERSECT.

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C
XIV 300 DX=0.0 $ Y2A=YA $ Y2B=YB
301 RATIOA=COSF(ALPHAR1)/V1 $ RATIOB=COSF(BETAR1)/V1
XXINC=XINC
XV 305 IF(PHI.LT.180.)306,336
C
C CALCULATION OF XACT,YACT WHEN PHI IS LESS THAN 180 DEG.
306 DX=DX+XXINC
307 V2=V1+VGRAD*DX
IF(ABSF(V2*RATIOA).GT.1.) 327,308
308 IF(ABSF(V2*RATIOB).GT.1.) 327,309
309 ALPHAR2=ACOSF(V2*RATIOA) $ BETAR2=ACOSF(V2*RATIOB)
DYA=DX/TANF((ALPHAR1+ALPHAR2)/2.)
DYB=DX/TANF((BETAR1+BETAR2)/2.)
313 Y2A=YA+DYA $ Y2B=YB+DYB
IF(BRGA) 325,314,314
XVI C TEST FOR INTERSECTION OF RAYS
314 IF(180.-BRGA) 325,520,315
315 IF(Y2A-Y2B) 316,328,306
316 IF((Y2B-Y2A).LT.YDIFF) 328,327
325 IF(Y2B-Y2A)326,328,306
326 IF((Y2A-Y2B).LT.YDIFF)328,327
327 DX=DX-XXINC $ XXINC=.1*XXINC $ GO TO 306
328 XACT=XA+DX $ YACT=Y2A $ GO TO 400
C
C CALCULATION OF XACT,YACT WHEN PHI IS GREATER THAN 180 DEG.
336 DX=DX+XXINC
C NOTE THAT SIGN OF DX IS ALWAYS +.
337 V2=V1-VGRAD*DX
IF(ABSF(V2*RATIOA).GT.1.) 357,338
338 IF(ABSF(V2*RATIOB).GT.1.) 357,339
339 ALPHAR2=2.*PI-ACOSF(V2*RATIOA)
BETAR2=2.*PI-ACOSF(V2*RATIOB)
DYA=DX/TANF((ALPHAR1+ALPHAR2)/2.)
DYB=DX/TANF((BETAR1+BETAR2)/2.)
C NOTE THAT SINCE SIGN OF DX WAS KEPT + THROUGHOUT, SIGN OF
C DY A AND DY B WILL BE THE OPPOSITE OF WHAT THEY SHOULD BE.
XVII 343 Y2A=YA-DYA $ Y2B=YB-DYB
C TEST FOR INTERSECTION OF RAYS
344 IF(180.-BRGA) 345,520,355
345 IF(Y2A-Y2B) 346,358,336
346 IF((Y2B-Y2A).LT.YDIFF) 358,357
355 IF(Y2B-Y2A) 356,358,336
356 IF((Y2A-Y2B).LT.YDIFF)358,357
357 DX=DX-XXINC $ XXINC=.1*XXINC $ GO TO 336
358 XACT=XB-DX $ YACT=Y2A $ GO TO 400
C
C ROUTINES FOR CALCULATION OF ERRORS
XVIII 400 XERR=XACT-XAPP $ YERR=YACT-YAPP
405 ERROR=SQRTF(XERR*XERR + YERR*YERR)
410 RACT = SQRTF(XACT*XACT + YACT*YACT)
415 RNGERR = RAPP - RACT

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C SUBTRACT RNGERR FROM RAPP TO GET RACT.
416 RELERR=ERROR/RAPP
C Z IS A DUMMY VARIABLE TO ENABLE USE OF SUBROUTINE ANGLES.
420 Z=0.0
XVIII 421 K=3 $ CALL ANGLES(Z,Z,XACT,YACT,GAMMA,K)
422 DELTA = PHI - GAMMA
C SUBTRACT ERRORS FROM PHI TO GET GAMMA.
425 K=4 $ CALL ANGLES(Z,Z,XERR,YERR,TAU,K)
427 BRGT = TAU - OMEGA
428 IF(BRGT)429,500,500
429 BRGT=BRGT+360.
Y
C
C CALCULATIONS COMPLETE, PRINT RESULTS.
C
500 PRINT 510, BRGP,RACT,V2,BRGA,BRGB,ERROR,BRGT,DELTA,
1RNGERR,RELERR
XIX 510 FORMAT (2X,F3.0,2X,F7.0,4X,F6.1,3X,2(F5.1,3X),F7.0,
13X,F5.1,3X,F4.1,2X,F8.0,3X,F6.4)
515 GO TO 600
520 PHI=PHI+10. $ PRINT 521, PHI
521 FORMAT(F5.0,24X,28HIMPOSSIBLE FIX(BRGP=180 DEG))
GO TO 600
530 PRINT 531, PHI
531 FORMAT (F5.0,24X,22HCRITICAL ANGLE LIMITED)
600 CONTINUE
Y
C
C INCREMENT RAPP AND GET NEW RESULTS.
C
XX 610 RAPP=RAPP+RAPPINC
C TEST TO SEE IF RAPP HAS EXCEEDED RAPPMAX. IF YES, READ
C NEW DATA, IF NOT, GET RESULTS FOR NEW RAPP.
Y
620 IF(RAPP-RAPPMAX) 170,170,120
XXI 900 CONTINUE
END
Y
C
C SUBROUTINE TO CALCULATE ANGLES FROM 0 TO 360 DEGREES
C USING TANGENTS.
C
SUBROUTINE ANGLES (A,B,C,D,ANGLE,K)
700 RPD = .01745329252
701 IF(D-B) 710,705,710
705 IF(C-A)706,738,707
706 ANGLE=270. $ GO TO 740
707 ANGLE=90. $ GO TO 740
710 ANGLER= ATANF((C-A)/(D-B)) $ ANGLE=ANGLER/RPD
715 IF((C-A)/(D-B))716,718,717
716 IF(C-A)720,730,722
717 IF(C-A) 722,736,740
718 IF(D-B) 730,738,736
720 ANGLE=ANGLE+360. $ GO TO 740
722 ANGLE=ANGLE+180. $ GO TO 740
730 ANGLE=180. $ GO TO 740
736 ANGLE=0. $ GO TO 740

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APPENDIX I

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738 GO TO(750,760,740,770),K
740 RETURN
750 PRINT 751      $ GO TO 740
751 FORMAT(35X,18HTARGET AT SENSOR A)
760 PRINT 761      $ GO TO 740
761 FORMAT(35X,18HTARGET AT SENSOR B)
770 PRINT 771      $ GO TO 740
771 FORMAT (35X,19HTARGET AT XAPP,YAPP)
      END
      END
      FINIS

```

-EXECUTE.

1500	.0001	.1		
100000	100000	500000	100000	10000
200000	100000	1000000	100000	10000
400000	100000	2000000	200000	10000
-999.	-999.	-999.	-999.	-999.

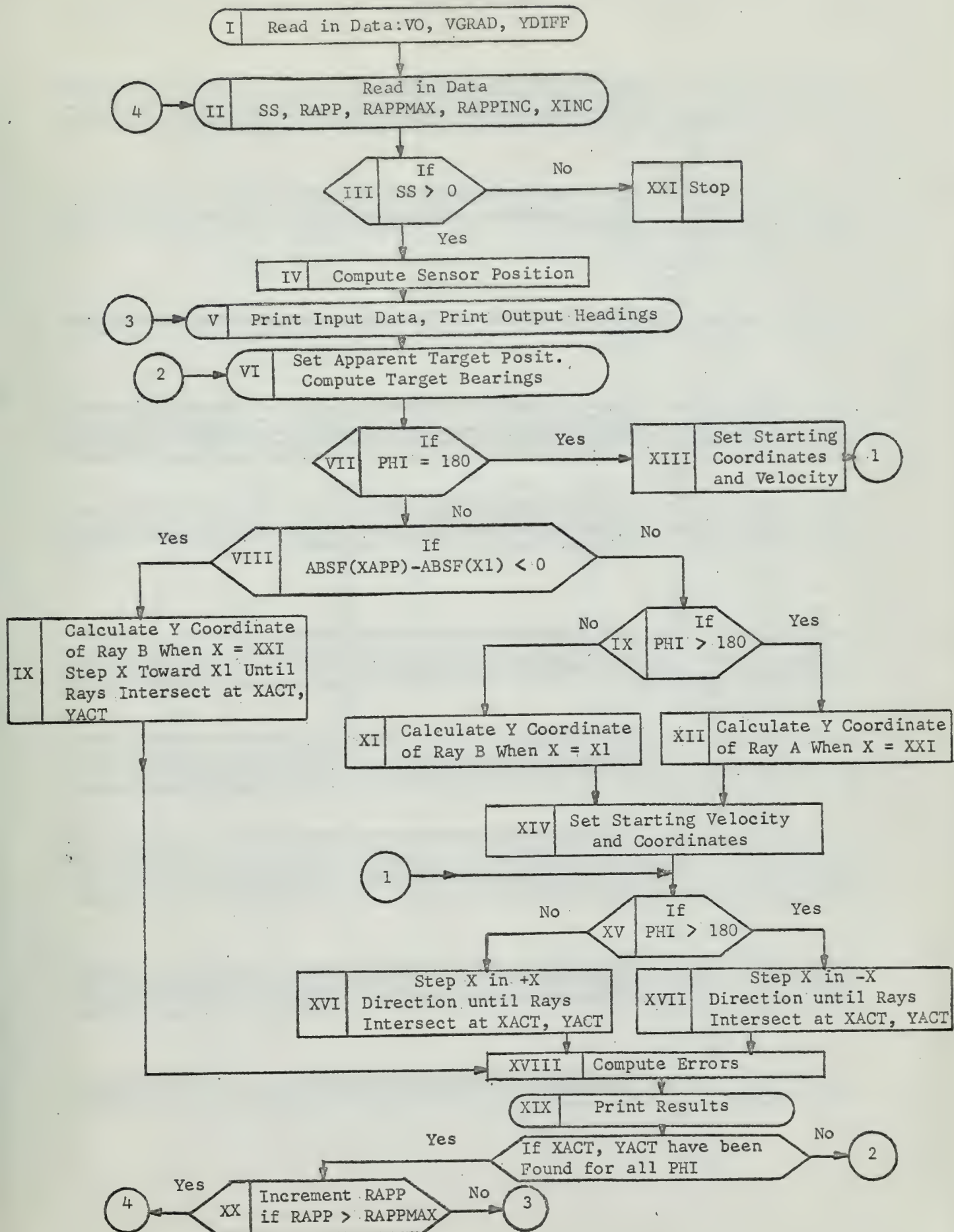


TABLE 1

Effect of Velocity Gradient (VGRAD = .0001)

OMEGA =	0	SS =	2000	RAPP =	10000	REDRNG =	5.00
	V0 =	1500.0	VGRAD =	.00010	YDIFF =	.1	
BRGP	RACT	V2	BRGA	BRGB	ERROR	BRGT	DELTA
10	9963	1500	11	9	37	195	0
20	9982	1500	22	18	18	222	0
30	9989	1500	33	27	11	238	0
40	9992	1500	44	36	8	259	0
50	9994	1500	55	45	5	277	0
60	9995	1500	66	54	4	290	0
70	9996	1500	77	64	3	308	0
80	9997	1500	88	74	3	325	0
90	9997	1500	99	84	1	339	0
100	9997	1500	105	94	0	350	0
110	9996	1500	112	104	0	362	0
120	9995	1500	124	115	0	378	0
130	9994	1500	135	126	4	391	0
140	9992	1500	147	137	8	405	0
150	9989	1500	151	147	3	419	0
160	9982	1500	160	158	1	434	0
170	9963	1500	170	168	3	449	0
180	9963	1500	180	178	7	464	0
190	9963	1500	190	188	1	479	0
200	9963	1500	200	191	8	494	0
210	1001	1499	210	203	0	509	0
220	1001	1499	220	213	8	524	0
230	1001	1499	230	224	1	539	0
240	1000	1499	240	234	8	554	0
250	1000	1499	250	245	6	569	0
260	1000	1499	260	255	4	584	0
270	1000	1499	270	267	3	599	0
280	1000	1499	280	277	2	614	0
290	1000	1499	290	289	1	629	0
300	1000	1499	300	301	6	644	0
310	1000	1499	310	313	8	659	0
320	1000	1499	320	324	5	674	0
330	1000	1499	330	335	3	689	0
340	1000	1499	340	345	4	704	0
350	1000	1499	350	356	5	719	0
360	1000	1499	360	367	6	734	0
370	1000	1499	370	377	8	749	0
380	1000	1499	380	389	1	764	0
390	1000	1499	390	401	6	779	0
400	1000	1499	400	413	8	794	0
410	1000	1499	410	424	5	809	0
420	1000	1499	420	435	3	824	0
430	1000	1499	430	445	4	839	0
440	1000	1499	440	456	5	854	0
450	1000	1499	450	467	6	869	0
460	1000	1499	460	477	8	884	0
470	1000	1499	470	489	1	899	0
480	1000	1499	480	501	6	914	0
490	1000	1499	490	513	8	929	0
500	1000	1499	500	524	5	944	0
510	1000	1499	510	535	3	959	0
520	1000	1499	520	545	4	974	0
530	1000	1499	530	556	5	989	0
540	1000	1499	540	567	6	1000	0
550	1000	1499	550	577	8	1000	0
560	1000	1499	560	589	1	1000	0
570	1000	1499	570	601	6	1000	0
580	1000	1499	580	613	8	1000	0
590	1000	1499	590	624	5	1000	0
600	1000	1499	600	635	3	1000	0
610	1000	1499	610	645	4	1000	0
620	1000	1499	620	656	5	1000	0
630	1000	1499	630	667	6	1000	0
640	1000	1499	640	677	8	1000	0
650	1000	1499	650	689	1	1000	0
660	1000	1499	660	701	6	1000	0
670	1000	1499	670	713	8	1000	0
680	1000	1499	680	724	5	1000	0
690	1000	1499	690	735	3	1000	0
700	1000	1499	700	745	4	1000	0
710	1000	1499	710	756	5	1000	0
720	1000	1499	720	767	6	1000	0
730	1000	1499	730	777	8	1000	0
740	1000	1499	740	789	1	1000	0
750	1000	1499	750	801	6	1000	0
760	1000	1499	760	813	8	1000	0
770	1000	1499	770	824	5	1000	0
780	1000	1499	780	835	3	1000	0
790	1000	1499	790	845	4	1000	0
800	1000	1499	800	856	5	1000	0
810	1000	1499	810	867	6	1000	0
820	1000	1499	820	877	8	1000	0
830	1000	1499	830	889	1	1000	0
840	1000	1499	840	901	6	1000	0
850	1000	1499	850	913	8	1000	0
860	1000	1499	860	924	5	1000	0
870	1000	1499	870	935	3	1000	0
880	1000	1499	880	945	4	1000	0
890	1000	1499	890	956	5	1000	0
900	1000	1499	900	967	6	1000	0
910	1000	1499	910	977	8	1000	0
920	1000	1499	920	989	1	1000	0
930	1000	1499	930	1001	6	1000	0
940	1000	1499	940	1013	8	1000	0
950	1000	1499	950	1024	5	1000	0
960	1000	1499	960	1035	3	1000	0
970	1000	1499	970	1045	4	1000	0
980	1000	1499	980	1056	5	1000	0
990	1000	1499	990	1067	6	1000	0
1000	1000	1499	1000	1077	8	1000	0

TABLE 2

Effect of Velocity Gradient (VGRAD = .00025)

OMEGA = 0	SS = 2000	RAPP = 10000	REDRNG = 5.00
V0 = 1500.0	VGRAD = .00025	YDIFF = .1	
BRGP	BRGA	BRGB	ERROR
10	1500.4	9.1	195.1
20	1500.8	18.2	222.4
30	1501.2	27.3	222.4
40	1501.6	36.4	222.4
50	1502.0	45.5	222.4
60	1502.4	54.6	222.4
70	1502.8	63.7	222.4
80	1503.2	72.8	222.4
90	1503.6	81.9	222.4
100	1504.0	91.0	222.4
110	1504.4	100.1	222.4
120	1504.8	109.2	222.4
130	1505.2	118.3	222.4
140	1505.6	127.4	222.4
150	1506.0	136.5	222.4
160	1506.4	145.6	222.4
170	1506.8	154.7	222.4
180	1507.2	163.8	222.4
190	1507.6	172.9	222.4
200	1508.0	182.0	222.4
210	1508.4	191.1	222.4
220	1508.8	200.2	222.4
230	1509.2	209.3	222.4
240	1509.6	218.4	222.4
250	1510.0	227.5	222.4
260	1510.4	236.6	222.4
270	1510.8	245.7	222.4
280	1511.2	254.8	222.4
290	1511.6	263.9	222.4
300	1512.0	273.0	222.4
310	1512.4	282.1	222.4
320	1512.8	291.2	222.4
330	1513.2	300.3	222.4
340	1513.6	309.4	222.4
350	1514.0	318.5	222.4
360	1514.4	327.6	222.4
370	1514.8	336.7	222.4
380	1515.2	345.8	222.4
390	1515.6	354.9	222.4
400	1516.0	364.0	222.4
410	1516.4	373.1	222.4
420	1516.8	382.2	222.4
430	1517.2	391.3	222.4
440	1517.6	400.4	222.4
450	1518.0	409.5	222.4
460	1518.4	418.6	222.4
470	1518.8	427.7	222.4
480	1519.2	436.8	222.4
490	1519.6	445.9	222.4
500	1520.0	455.0	222.4
510	1520.4	464.1	222.4
520	1520.8	473.2	222.4
530	1521.2	482.3	222.4
540	1521.6	491.4	222.4
550	1522.0	500.5	222.4
560	1522.4	509.6	222.4
570	1522.8	518.7	222.4
580	1523.2	527.8	222.4
590	1523.6	536.9	222.4
600	1524.0	546.0	222.4
610	1524.4	555.1	222.4
620	1524.8	564.2	222.4
630	1525.2	573.3	222.4
640	1525.6	582.4	222.4
650	1526.0	591.5	222.4
660	1526.4	600.6	222.4
670	1526.8	609.7	222.4
680	1527.2	618.8	222.4
690	1527.6	627.9	222.4
700	1528.0	637.0	222.4
710	1528.4	646.1	222.4
720	1528.8	655.2	222.4
730	1529.2	664.3	222.4
740	1529.6	673.4	222.4
750	1530.0	682.5	222.4
760	1530.4	691.6	222.4
770	1530.8	700.7	222.4
780	1531.2	709.8	222.4
790	1531.6	718.9	222.4
800	1532.0	728.0	222.4
810	1532.4	737.1	222.4
820	1532.8	746.2	222.4
830	1533.2	755.3	222.4
840	1533.6	764.4	222.4
850	1534.0	773.5	222.4
860	1534.4	782.6	222.4
870	1534.8	791.7	222.4
880	1535.2	800.8	222.4
890	1535.6	809.9	222.4
900	1536.0	819.0	222.4
910	1536.4	828.1	222.4
920	1536.8	837.2	222.4
930	1537.2	846.3	222.4
940	1537.6	855.4	222.4
950	1538.0	864.5	222.4
960	1538.4	873.6	222.4
970	1538.8	882.7	222.4
980	1539.2	891.8	222.4
990	1539.6	900.9	222.4
1000	1540.0	910.0	222.4
1010	1540.4	919.1	222.4
1020	1540.8	928.2	222.4
1030	1541.2	937.3	222.4
1040	1541.6	946.4	222.4
1050	1542.0	955.5	222.4
1060	1542.4	964.6	222.4
1070	1542.8	973.7	222.4
1080	1543.2	982.8	222.4
1090	1543.6	991.9	222.4
1100	1544.0	1001.0	222.4
1110	1544.4	1010.1	222.4
1120	1544.8	1019.2	222.4
1130	1545.2	1028.3	222.4
1140	1545.6	1037.4	222.4
1150	1546.0	1046.5	222.4
1160	1546.4	1055.6	222.4
1170	1546.8	1064.7	222.4
1180	1547.2	1073.8	222.4
1190	1547.6	1082.9	222.4
1200	1548.0	1092.0	222.4
1210	1548.4	1101.1	222.4
1220	1548.8	1110.2	222.4
1230	1549.2	1119.3	222.4
1240	1549.6	1128.4	222.4
1250	1550.0	1137.5	222.4
1260	1550.4	1146.6	222.4
1270	1550.8	1155.7	222.4
1280	1551.2	1164.8	222.4
1290	1551.6	1173.9	222.4
1300	1552.0	1183.0	222.4
1310	1552.4	1192.1	222.4
1320	1552.8	1201.2	222.4
1330	1553.2	1210.3	222.4
1340	1553.6	1219.4	222.4
1350	1554.0	1228.5	222.4
1360	1554.4	1237.6	222.4
1370	1554.8	1246.7	222.4
1380	1555.2	1255.8	222.4
1390	1555.6	1264.9	222.4
1400	1556.0	1274.0	222.4
1410	1556.4	1283.1	222.4
1420	1556.8	1292.2	222.4
1430	1557.2	1301.3	222.4
1440	1557.6	1310.4	222.4
1450	1558.0	1319.5	222.4
1460	1558.4	1328.6	222.4
1470	1558.8	1337.7	222.4
1480	1559.2	1346.8	222.4
1490	1559.6	1355.9	222.4
1500	1560.0	1365.0	222.4
1510	1560.4	1374.1	222.4
1520	1560.8	1383.2	222.4
1530	1561.2	1392.3	222.4
1540	1561.6	1401.4	222.4
1550	1562.0	1410.5	222.4
1560	1562.4	1419.6	222.4
1570	1562.8	1428.7	222.4
1580	1563.2	1437.8	222.4
1590	1563.6	1446.9	222.4
1600	1564.0	1456.0	222.4
1610	1564.4	1465.1	222.4
1620	1564.8	1474.2	222.4
1630	1565.2	1483.3	222.4
1640	1565.6	1492.4	222.4
1650	1566.0	1501.5	222.4
1660	1566.4	1510.6	222.4
1670	1566.8	1519.7	222.4
1680	1567.2	1528.8	222.4
1690	1567.6	1537.9	222.4
1700	1568.0	1547.0	222.4
1710	1568.4	1556.1	222.4
1720	1568.8	1565.2	222.4
1730	1569.2	1574.3	222.4
1740	1569.6	1583.4	222.4
1750	1570.0	1592.5	222.4
1760	1570.4	1601.6	222.4
1770	1570.8	1610.7	222.4
1780	1571.2	1619.8	222.4
1790	1571.6	1628.9	222.4
1800	1572.0	1638.0	222.4
1810	1572.4	1647.1	222.4
1820	1572.8	1656.2	222.4
1830	1573.2	1665.3	222.4
1840	1573.6	1674.4	222.4
1850	1574.0	1683.5	222.4
1860	1574.4	1692.6	222.4
1870	1574.8	1701.7	222.4
1880	1575.2	1710.8	222.4
1890	1575.6	1719.9	222.4
1900	1576.0	1729.0	222.4
1910	1576.4	1738.1	222.4
1920	1576.8	1747.2	222.4
1930	1577.2	1756.3	222.4
1940	1577.6	1765.4	222.4
1950	1578.0	1774.5	222.4
1960	1578.4	1783.6	222.4
1970	1578.8	1792.7	222.4
1980	1579.2	1801.8	222.4
1990	1579.6	1810.9	222.4
2000	1580.0	1820.0	222.4
2010	1580.4	1829.1	222.4
2020	1580.8	1838.2	222.4
2030	1581.2	1847.3	222.4
2040	1581.6	1856.4	222.4
2050	1582.0	1865.5	222.4
2060	1582.4	1874.6	222.4
2070	1582.8	1883.7	222.4
2080	1583.2	1892.8	222.4
2090	1583.6	1901.9	222.4
2100	1584.0	1911.0	222.4
2110	1584.4	1920.1	222.4
2120	1584.8	1929.2	222.4
2130	1585.2	1938.3	222.4
2140	1585.6	1947.4	222.4
2150	1586.0	1956.5	222.4
2160	1586.4	1965.6	222.4
2170	1586.8	1974.7	222.4
2180	1587.2	1983.8	222.4
2190	1587.6	1992.9	222.4
2200	1588.0	2002.0	222.4
2210	1588.4	2011.1	222.4
2220	1588.8	2020.2	222.4
2230	1589.2	2029.3	222.4
2240	1589.6	2038.4	222.4
2250	1590.0	2047.5	222.4
2260	1590.4	2056.6	222.4
2270	1590.8	2065.7	222.4
2280	1591.2	2074.8	222.4
2290	1591.6	2083.9	222.4
2300	1592.0	2093.0	222.4
2310	1592.4	2102.1	222.4
2320	1592.8	2111.2	222.4
2330	1593.2	2120.3	222.4
2340	1593.6	2129.4	222.4
2350	1594.0	2138.5	222.4
2360	1594.4	2147.6	222.4
2370	1594.8	2156.7	222.4
2380	1595.2	2165.8	222.4
2390	1595.6	2174.9	222.4
2400	1596.0	2184.0	222.4
2410	1596.4	2193.1	222.4
2420	1596.8	2202.2	222.4
2430	1597.2	2211.3	222.4
2440	1597.6	2220.4	222.4
2450	1598.0	2229.5	222.4
2460	1598.4	2238.6	222.4
2470	1598.8	2247.7	222.4
2480	1599.2	2256.8	222.4
2490	1599.6	2265.9	222.4
2500	1600.0	2275.0	222.4
2510	1600.4	2284.1	222.4
2520	1600.8	2293.2	222.4
2530	1601.2	2302.3	222.4
2540	1601.6	2311.4	222.4
2550	1602.0	2320.5	222.4
2560	1602.4	2329.6	222.4
2570	1602.8	2338.7	222.4
2580	1603.2	2347.8	222.4
2590	1603.6	2356.9	222.4
2600	1604.0	2366.0	222.4
2610	1604.4	2375.1	222.4
2620	1604.8	2384.2	222.4
2630	1605.2</		

APPENDIX III

TABLE 3

Effect of Velocity Gradient (VGRAD = .0005)

OMEGA = 0		SS = 2000		RAPP = 10000		REDRNG = 5.00	
VO = 1500.0		VGRAD = .00050		YDIFF = .1			
BRGP	VO	BRGA	BRGB	ERROR	DEGT	DELTA	RELE
10	1500	1087.5	109.1	184.5	195.1	1.1	0184
20	1501	1012.3	187.4	191.5	210.4	1.1	0091
30	1503	1044.2	365.5	542.9	237.9	1.1	0059
40	1504	1055.9	554.7	420.7	249.6	1.1	0032
50	1504	1075.5	744.8	220.7	269.4	1.1	0025
60	1504	1090.9	944.3	167.8	270.6	0.0	0018
70	1504	1104.7	1044.8	170.5	273.0	0.0	0017
80	1504	1115.2	1125.0	222.2	280.4	0.0	0022
90	1504	1124.3	1136.6	234.5	290.2	0.0	0018
100	1504	1134.2	1147.8	251.1	302.5	0.1	0023
110	1503	1145.1	1157.9	291.5	315.0	1.1	0033
120	1503	1157.0	1168.9	345.5	334.4	1.1	0045
130	1503	1170.9	1178.9	384.5	354.9	1.1	0059
140	1501	1184.8	1188.9	418.4	374.9	1.1	0091
150	1500	1198.7	1199.1	451.3	395.1	1.1	0184
160	1499	1207.6	1202.3	483.0	410.4	1.1	0230
170	1498	1216.5	1214.4	515.5	427.9	1.1	0336
180	1497	1225.4	1224.5	547.8	445.1	1.1	0433
190	1496	1234.3	1234.5	579.9	462.6	1.1	0530
200	1495	1243.2	1244.5	611.9	480.1	1.1	0627
210	1494	1252.1	1254.5	643.8	497.4	1.1	0718
220	1493	1261.0	1264.5	675.7	514.7	1.1	0817
230	1492	1269.9	1274.5	707.6	532.0	1.1	0912
240	1491	1278.8	1284.5	739.5	549.2	1.1	1003
250	1490	1287.7	1294.5	771.4	566.4	1.1	1094
260	1489	1296.6	1304.5	803.3	583.6	1.1	1185
270	1488	1305.5	1314.5	835.2	600.9	1.1	1276
280	1487	1314.4	1324.5	867.1	618.2	1.1	1367
290	1486	1323.3	1334.5	899.0	635.5	1.1	1458
300	1485	1332.2	1344.5	930.9	652.8	1.1	1549
310	1484	1341.1	1354.5	962.8	670.1	1.1	1640
320	1483	1350.0	1364.5	994.7	687.4	1.1	1731
330	1482	1358.9	1374.5	1026.6	704.7	1.1	1822
340	1481	1367.8	1384.5	1058.5	722.0	1.1	1913
350	1480	1376.7	1394.5	1090.4	739.3	1.1	2004
360	1479	1385.6	1404.5	1122.3	756.6	1.1	2095
370	1478	1394.5	1414.5	1154.2	773.9	1.1	2186
380	1477	1403.4	1424.5	1186.1	791.2	1.1	2277
390	1476	1412.3	1434.5	1218.0	808.5	1.1	2368
400	1475	1421.2	1444.5	1249.9	825.8	1.1	2459
410	1474	1430.1	1454.5	1281.8	843.1	1.1	2550
420	1473	1439.0	1464.5	1313.7	860.4	1.1	2641
430	1472	1447.9	1474.5	1345.6	877.7	1.1	2732
440	1471	1456.8	1484.5	1377.5	895.0	1.1	2823
450	1470	1465.7	1494.5	1409.4	912.3	1.1	2914
460	1469	1474.6	1504.5	1441.3	929.6	1.1	3005
470	1468	1483.5	1514.5	1473.2	946.9	1.1	3096
480	1467	1492.4	1524.5	1505.1	964.2	1.1	3187
490	1466	1501.3	1534.5	1537.0	981.5	1.1	3278
500	1465	1510.2	1544.5	1568.9	998.8	1.1	3369
510	1464	1519.1	1554.5	1600.8	1016.1	1.1	3460
520	1463	1528.0	1564.5	1632.7	1033.4	1.1	3551
530	1462	1536.9	1574.5	1664.6	1050.7	1.1	3642
540	1461	1545.8	1584.5	1696.5	1068.0	1.1	3733
550	1460	1554.7	1594.5	1728.4	1085.3	1.1	3824
560	1459	1563.6	1604.5	1760.3	1102.6	1.1	3915
570	1458	1572.5	1614.5	1792.2	1119.9	1.1	4006
580	1457	1581.4	1624.5	1824.1	1137.2	1.1	4097
590	1456	1590.3	1634.5	1856.0	1154.5	1.1	4188
600	1455	1599.2	1644.5	1887.9	1171.8	1.1	4279
610	1454	1608.1	1654.5	1919.8	1189.1	1.1	4370
620	1453	1617.0	1664.5	1951.7	1206.4	1.1	4461
630	1452	1625.9	1674.5	1983.6	1223.7	1.1	4552
640	1451	1634.8	1684.5	2015.5	1241.0	1.1	4643
650	1450	1643.7	1694.5	2047.4	1258.3	1.1	4734
660	1449	1652.6	1704.5	2079.3	1275.6	1.1	4825
670	1448	1661.5	1714.5	2111.2	1292.9	1.1	4916
680	1447	1670.4	1724.5	2143.1	1310.2	1.1	5007
690	1446	1679.3	1734.5	2175.0	1327.5	1.1	5098
700	1445	1688.2	1744.5	2206.9	1344.8	1.1	5189
710	1444	1697.1	1754.5	2238.8	1362.1	1.1	5280
720	1443	1706.0	1764.5	2270.7	1379.4	1.1	5371
730	1442	1714.9	1774.5	2302.6	1396.7	1.1	5462
740	1441	1723.8	1784.5	2334.5	1414.0	1.1	5553
750	1440	1732.7	1794.5	2366.4	1431.3	1.1	5644
760	1439	1741.6	1804.5	2398.3	1448.6	1.1	5735
770	1438	1750.5	1814.5	2430.2	1465.9	1.1	5826
780	1437	1759.4	1824.5	2462.1	1483.2	1.1	5917
790	1436	1768.3	1834.5	2494.0	1500.5	1.1	6008
800	1435	1777.2	1844.5	2525.9	1517.8	1.1	6099
810	1434	1786.1	1854.5	2557.8	1535.1	1.1	6190
820	1433	1795.0	1864.5	2589.7	1552.4	1.1	6281
830	1432	1803.9	1874.5	2621.6	1569.7	1.1	6372
840	1431	1812.8	1884.5	2653.5	1587.0	1.1	6463
850	1430	1821.7	1894.5	2685.4	1604.3	1.1	6554
860	1429	1830.6	1904.5	2717.3	1621.6	1.1	6645
870	1428	1839.5	1914.5	2749.2	1638.9	1.1	6736
880	1427	1848.4	1924.5	2781.1	1656.2	1.1	6827
890	1426	1857.3	1934.5	2813.0	1673.5	1.1	6918
900	1425	1866.2	1944.5	2844.9	1690.8	1.1	7009
910	1424	1875.1	1954.5	2876.8	1708.1	1.1	7100
920	1423	1884.0	1964.5	2908.7	1725.4	1.1	7191
930	1422	1892.9	1974.5	2940.6	1742.7	1.1	7282
940	1421	1901.8	1984.5	2972.5	1760.0	1.1	7373
950	1420	1910.7	1994.5	3004.4	1777.3	1.1	7464
960	1419	1919.6	2004.5	3036.3	1794.6	1.1	7555
970	1418	1928.5	2014.5	3068.2	1811.9	1.1	7646
980	1417	1937.4	2024.5	3100.1	1829.2	1.1	7737
990	1416	1946.3	2034.5	3132.0	1846.5	1.1	7828
1000	1415	1955.2	2044.5	3163.9	1863.8	1.1	7919

TABLE 4

Effect of Sensor Separation (SS = 1 km.)

OMEGA = 0	SS = 1000	RAPP = 5000	REDRNG = 5.00
V0 = 1500.0	VGRAD = .00050	YDIFF = .1	
BRGP	BRGA	BRGB	ERROR
10	11.1	9.1	195.1
20	23.1	18.2	110.4
30	34.1	26.5	223.8
40	44.1	34.5	222.4
50	54.1	42.5	222.4
60	64.1	50.5	222.4
70	74.1	58.5	222.4
80	84.1	66.5	222.4
90	94.1	74.5	222.4
100	104.1	82.5	222.4
110	114.1	90.5	222.4
120	124.1	98.5	222.4
130	134.1	106.5	222.4
140	144.1	114.5	222.4
150	154.1	122.5	222.4
160	164.1	130.5	222.4
170	174.1	138.5	222.4
180	184.1	146.5	222.4
190	194.1	154.5	222.4
200	204.1	162.5	222.4
210	214.1	170.5	222.4
220	224.1	178.5	222.4
230	234.1	186.5	222.4
240	244.1	194.5	222.4
250	254.1	202.5	222.4
260	264.1	210.5	222.4
270	274.1	218.5	222.4
280	284.1	226.5	222.4
290	294.1	234.5	222.4
300	304.1	242.5	222.4
310	314.1	250.5	222.4
320	324.1	258.5	222.4
330	334.1	266.5	222.4
340	344.1	274.5	222.4
350	354.1	282.5	222.4
360	364.1	290.5	222.4
370	374.1	298.5	222.4
380	384.1	306.5	222.4
390	394.1	314.5	222.4
400	404.1	322.5	222.4
410	414.1	330.5	222.4
420	424.1	338.5	222.4
430	434.1	346.5	222.4
440	444.1	354.5	222.4
450	454.1	362.5	222.4
460	464.1	370.5	222.4
470	474.1	378.5	222.4
480	484.1	386.5	222.4
490	494.1	394.5	222.4
500	504.1	402.5	222.4
510	514.1	410.5	222.4
520	524.1	418.5	222.4
530	534.1	426.5	222.4
540	544.1	434.5	222.4
550	554.1	442.5	222.4
560	564.1	450.5	222.4
570	574.1	458.5	222.4
580	584.1	466.5	222.4
590	594.1	474.5	222.4
600	604.1	482.5	222.4
610	614.1	490.5	222.4
620	624.1	498.5	222.4
630	634.1	506.5	222.4
640	644.1	514.5	222.4
650	654.1	522.5	222.4
660	664.1	530.5	222.4
670	674.1	538.5	222.4
680	684.1	546.5	222.4
690	694.1	554.5	222.4
700	704.1	562.5	222.4
710	714.1	570.5	222.4
720	724.1	578.5	222.4
730	734.1	586.5	222.4
740	744.1	594.5	222.4
750	754.1	602.5	222.4
760	764.1	610.5	222.4
770	774.1	618.5	222.4
780	784.1	626.5	222.4
790	794.1	634.5	222.4
800	804.1	642.5	222.4
810	814.1	650.5	222.4
820	824.1	658.5	222.4
830	834.1	666.5	222.4
840	844.1	674.5	222.4
850	854.1	682.5	222.4
860	864.1	690.5	222.4
870	874.1	698.5	222.4
880	884.1	706.5	222.4
890	894.1	714.5	222.4
900	904.1	722.5	222.4
910	914.1	730.5	222.4
920	924.1	738.5	222.4
930	934.1	746.5	222.4
940	944.1	754.5	222.4
950	954.1	762.5	222.4
960	964.1	770.5	222.4
970	974.1	778.5	222.4
980	984.1	786.5	222.4
990	994.1	794.5	222.4
1000	1004.1	802.5	222.4
1010	1014.1	810.5	222.4
1020	1024.1	818.5	222.4
1030	1034.1	826.5	222.4
1040	1044.1	834.5	222.4
1050	1054.1	842.5	222.4
1060	1064.1	850.5	222.4
1070	1074.1	858.5	222.4
1080	1084.1	866.5	222.4
1090	1094.1	874.5	222.4
1100	1104.1	882.5	222.4
1110	1114.1	890.5	222.4
1120	1124.1	898.5	222.4
1130	1134.1	906.5	222.4
1140	1144.1	914.5	222.4
1150	1154.1	922.5	222.4
1160	1164.1	930.5	222.4
1170	1174.1	938.5	222.4
1180	1184.1	946.5	222.4
1190	1194.1	954.5	222.4
1200	1204.1	962.5	222.4
1210	1214.1	970.5	222.4
1220	1224.1	978.5	222.4
1230	1234.1	986.5	222.4
1240	1244.1	994.5	222.4
1250	1254.1	1002.5	222.4
1260	1264.1	1010.5	222.4
1270	1274.1	1018.5	222.4
1280	1284.1	1026.5	222.4
1290	1294.1	1034.5	222.4
1300	1304.1	1042.5	222.4
1310	1314.1	1050.5	222.4
1320	1324.1	1058.5	222.4
1330	1334.1	1066.5	222.4
1340	1344.1	1074.5	222.4
1350	1354.1	1082.5	222.4
1360	1364.1	1090.5	222.4
1370	1374.1	1098.5	222.4
1380	1384.1	1106.5	222.4
1390	1394.1	1114.5	222.4
1400	1404.1	1122.5	222.4
1410	1414.1	1130.5	222.4
1420	1424.1	1138.5	222.4
1430	1434.1	1146.5	222.4
1440	1444.1	1154.5	222.4
1450	1454.1	1162.5	222.4
1460	1464.1	1170.5	222.4
1470	1474.1	1178.5	222.4
1480	1484.1	1186.5	222.4
1490	1494.1	1194.5	222.4
1500	1504.1	1202.5	222.4
1510	1514.1	1210.5	222.4
1520	1524.1	1218.5	222.4
1530	1534.1	1226.5	222.4
1540	1544.1	1234.5	222.4
1550	1554.1	1242.5	222.4
1560	1564.1	1250.5	222.4
1570	1574.1	1258.5	222.4
1580	1584.1	1266.5	222.4
1590	1594.1	1274.5	222.4
1600	1604.1	1282.5	222.4
1610	1614.1	1290.5	222.4
1620	1624.1	1298.5	222.4
1630	1634.1	1306.5	222.4
1640	1644.1	1314.5	222.4
1650	1654.1	1322.5	222.4
1660	1664.1	1330.5	222.4
1670	1674.1	1338.5	222.4
1680	1684.1	1346.5	222.4
1690	1694.1	1354.5	222.4
1700	1704.1	1362.5	222.4
1710	1714.1	1370.5	222.4
1720	1724.1	1378.5	222.4
1730	1734.1	1386.5	222.4
1740	1744.1	1394.5	222.4
1750	1754.1	1402.5	222.4
1760	1764.1	1410.5	222.4
1770	1774.1	1418.5	222.4
1780	1784.1	1426.5	222.4
1790	1794.1	1434.5	222.4
1800	1804.1	1442.5	222.4
1810	1814.1	1450.5	222.4
1820	1824.1	1458.5	222.4
1830	1834.1	1466.5	222.4
1840	1844.1	1474.5	222.4
1850	1854.1	1482.5	222.4
1860	1864.1	1490.5	222.4
1870	1874.1	1498.5	222.4
1880	1884.1	1506.5	222.4
1890	1894.1	1514.5	222.4
1900	1904.1	1522.5	222.4
1910	1914.1	1530.5	222.4
1920	1924.1	1538.5	222.4
1930	1934.1	1546.5	222.4
1940	1944.1	1554.5	222.4
1950	1954.1	1562.5	222.4
1960	1964.1	1570.5	222.4
1970	1974.1	1578.5	222.4
1980	1984.1	1586.5	222.4
1990	1994.1	1594.5	222.4
2000	2004.1	1602.5	222.4
2010	2014.1	1610.5	222.4
2020	2024.1	1618.5	222.4
2030	2034.1	1626.5	222.4
2040	2044.1	1634.5	222.4
2050	2054.1	1642.5	222.4
2060	2064.1	1650.5	222.4
2070	2074.1	1658.5	222.4
2080	2084.1	1666.5	222.4
2090	2094.1	1674.5	222.4
2100	2104.1	1682.5	222.4
2110	2114.1	1690.5	222.4
2120	2124.1	1698.5	222.4
2130	2134.1	1706.5	222.4
2140	2144.1	1714.5	222.4
2150	2154.1	1722.5	222.4
2160	2164.1	1730.5	222.4
2170	2174.1	1738.5	222.4
2180	2184.1	1746.5	222.4
2190	2194.1	1754.5	222.4
2200	2204.1	1762.5	222.4
2210	2214.1	1770.5	222.4
2220	2224.1	1778.5	222.4
2230	2234.1	1786.5	222.4
2240	2244.1	1794.5	222.4
2250	2254.1	1802.5	222.4
2260	2264.1	1810.5	222.4
2270	2274.1	1818.5	222.4
2280	2284.1	1826.5	222.4
2290	2294.1	1834.5	222.4
2300	2304.1	1842.5	222.4
2310	2314.1	1850.5	222.4
2320	2324.1	1858.5	222.4
2330	2334.1	1866.5	222.4
2340	2344.1	1874.5	222.4
2350	2354.1	1882.5	222.4
2360	2364.1	1890.5	222.4
2370	2374.1	1898.5	222.4
2380	2384.1	1906.5	222.4
2390	2394.1	1914.5	222.4
2400	2404.1	1922.5	222.4
2410	2414.1	1930.5	222.4
2420	2424.1	1938.5	222.4
2430	2434.1	1946.5	222.4
2440	2444.1	1954.5	222.4
2450	2454.1	1962.5	222.4
2460	2464.1	1970.5	222.4
2470	2474.1	1978.5	222.4
2480	2484.1	1986.5	222.4
2490	2494.1	1994.5	222.4
2500	2504.1	2002.5	222.4
2510	2514.1	2010.5	222.4
2520	2524.1	2018.5	222.4
2530	2534.1	2026.5	222.4
2540	2544.1	2034.5	222.4
2550	2554.1	2042.5	222.4
2560	2564.1	2050.5	222.4
2570	2574.1	2058.5	222.4
2580	2584.1	2066.5	222.4
2590	2594.1	2074.5	222.4
2600	2604.1	2082.5	222.4
2610	2614.1	2090.5	222.4
2620	2624.1	2098.5	222.4
2630	2634.1	2106.5	222.4
2640	2644.1	2114.5	222.4
2650	2654.1	2122.5	222.4
2660			

APPENDIX III

TABLE 5

Effect of Sensor Separation (SS = 5 km.)

OMEGA = 0	SS = 5000	RAPP = .00050	REDRNG = 1.00
VO = 1500.0	YDIFF = .1		
BRGP	BRGB	ERROR	DELTA
10	130	36.3	1
20	130	19.1	1
30	130	13.6	1
40	130	10.7	1
50	130	8.7	1
60	130	7.5	1
70	130	6.7	1
80	130	6.2	1
90	130	5.9	1
100	130	5.7	1
110	130	5.5	1
120	130	5.4	1
130	130	5.3	1
140	130	5.2	1
150	130	5.1	1
160	130	5.0	1
170	130	4.9	1
180	130	4.8	1
190	130	4.7	1
200	130	4.6	1
210	130	4.5	1
220	130	4.4	1
230	130	4.3	1
240	130	4.2	1
250	130	4.1	1
260	130	4.0	1
270	130	3.9	1
280	130	3.8	1
290	130	3.7	1
300	130	3.6	1
310	130	3.5	1
320	130	3.4	1
330	130	3.3	1
340	130	3.2	1
350	130	3.1	1
360	130	3.0	1
370	130	2.9	1
380	130	2.8	1
390	130	2.7	1
400	130	2.6	1
410	130	2.5	1
420	130	2.4	1
430	130	2.3	1
440	130	2.2	1
450	130	2.1	1
460	130	2.0	1
470	130	1.9	1
480	130	1.8	1
490	130	1.7	1
500	130	1.6	1
510	130	1.5	1
520	130	1.4	1
530	130	1.3	1
540	130	1.2	1
550	130	1.1	1
560	130	1.0	1
570	130	0.9	1
580	130	0.8	1
590	130	0.7	1
600	130	0.6	1
610	130	0.5	1
620	130	0.4	1
630	130	0.3	1
640	130	0.2	1
650	130	0.1	1
660	130	0.0	1
670	130	0.0	1
680	130	0.0	1
690	130	0.0	1
700	130	0.0	1
710	130	0.0	1
720	130	0.0	1
730	130	0.0	1
740	130	0.0	1
750	130	0.0	1
760	130	0.0	1
770	130	0.0	1
780	130	0.0	1
790	130	0.0	1
800	130	0.0	1
810	130	0.0	1
820	130	0.0	1
830	130	0.0	1
840	130	0.0	1
850	130	0.0	1
860	130	0.0	1
870	130	0.0	1
880	130	0.0	1
890	130	0.0	1
900	130	0.0	1
910	130	0.0	1
920	130	0.0	1
930	130	0.0	1
940	130	0.0	1
950	130	0.0	1
960	130	0.0	1
970	130	0.0	1
980	130	0.0	1
990	130	0.0	1
1000	130	0.0	1
1010	130	0.0	1
1020	130	0.0	1
1030	130	0.0	1
1040	130	0.0	1
1050	130	0.0	1
1060	130	0.0	1
1070	130	0.0	1
1080	130	0.0	1
1090	130	0.0	1
1100	130	0.0	1
1110	130	0.0	1
1120	130	0.0	1
1130	130	0.0	1
1140	130	0.0	1
1150	130	0.0	1
1160	130	0.0	1
1170	130	0.0	1
1180	130	0.0	1
1190	130	0.0	1
1200	130	0.0	1
1210	130	0.0	1
1220	130	0.0	1
1230	130	0.0	1
1240	130	0.0	1
1250	130	0.0	1
1260	130	0.0	1
1270	130	0.0	1
1280	130	0.0	1
1290	130	0.0	1
1300	130	0.0	1
1310	130	0.0	1
1320	130	0.0	1
1330	130	0.0	1
1340	130	0.0	1
1350	130	0.0	1
1360	130	0.0	1
1370	130	0.0	1
1380	130	0.0	1
1390	130	0.0	1
1400	130	0.0	1
1410	130	0.0	1
1420	130	0.0	1
1430	130	0.0	1
1440	130	0.0	1
1450	130	0.0	1
1460	130	0.0	1
1470	130	0.0	1
1480	130	0.0	1
1490	130	0.0	1
1500	130	0.0	1
1510	130	0.0	1
1520	130	0.0	1
1530	130	0.0	1
1540	130	0.0	1
1550	130	0.0	1
1560	130	0.0	1
1570	130	0.0	1
1580	130	0.0	1
1590	130	0.0	1
1600	130	0.0	1
1610	130	0.0	1
1620	130	0.0	1
1630	130	0.0	1
1640	130	0.0	1
1650	130	0.0	1
1660	130	0.0	1
1670	130	0.0	1
1680	130	0.0	1
1690	130	0.0	1
1700	130	0.0	1
1710	130	0.0	1
1720	130	0.0	1
1730	130	0.0	1
1740	130	0.0	1
1750	130	0.0	1
1760	130	0.0	1
1770	130	0.0	1
1780	130	0.0	1
1790	130	0.0	1
1800	130	0.0	1
1810	130	0.0	1
1820	130	0.0	1
1830	130	0.0	1
1840	130	0.0	1
1850	130	0.0	1
1860	130	0.0	1
1870	130	0.0	1
1880	130	0.0	1
1890	130	0.0	1
1900	130	0.0	1
1910	130	0.0	1
1920	130	0.0	1
1930	130	0.0	1
1940	130	0.0	1
1950	130	0.0	1
1960	130	0.0	1
1970	130	0.0	1
1980	130	0.0	1
1990	130	0.0	1
2000	130	0.0	1
2010	130	0.0	1
2020	130	0.0	1
2030	130	0.0	1
2040	130	0.0	1
2050	130	0.0	1
2060	130	0.0	1
2070	130	0.0	1
2080	130	0.0	1
2090	130	0.0	1
2100	130	0.0	1
2110	130	0.0	1
2120	130	0.0	1
2130	130	0.0	1
2140	130	0.0	1
2150	130	0.0	1
2160	130	0.0	1
2170	130	0.0	1
2180	130	0.0	1
2190	130	0.0	1
2200	130	0.0	1
2210	130	0.0	1
2220	130	0.0	1
2230	130	0.0	1
2240	130	0.0	1
2250	130	0.0	1
2260	130	0.0	1
2270	130	0.0	1
2280	130	0.0	1
2290	130	0.0	1
2300	130	0.0	1
2310	130	0.0	1
2320	130	0.0	1
2330	130	0.0	1
2340	130	0.0	1
2350	130	0.0	1
2360	130	0.0	1
2370	130	0.0	1
2380	130	0.0	1
2390	130	0.0	1
2400	130	0.0	1
2410	130	0.0	1
2420	130	0.0	1
2430	130	0.0	1
2440	130	0.0	1
2450	130	0.0	1
2460	130	0.0	1
2470	130	0.0	1
2480	130	0.0	1
2490	130	0.0	1
2500	130	0.0	1
2510	130	0.0	1
2520	130	0.0	1
2530	130	0.0	1
2540	130	0.0	1
2550	130	0.0	1
2560	130	0.0	1
2570	130	0.0	1
2580	130	0.0	1
2590	130	0.0	1
2600	130	0.0	1
2610	130	0.0	1
2620	130	0.0	1
2630	130	0.0	1
2640	130	0.0	1
2650	130	0.0	1
2660	130	0.0	1
2670	130	0.0	1
2680	130	0.0	1
2690	130	0.0	1
2700	130	0.0	1
2710	130	0.0	1
2720	130	0.0	1
2730	130	0.0	1
2740	130	0.0	1
2750	130	0.0	1
2760	130	0.0	1
2770	130	0.0	1
2780	130	0.0	1
2790	130	0.0	1
2800	130	0.0	1
2810	130	0.0	1
2820	130	0.0	1
2830	130	0.0	1
2840	130	0.0	1
2850	130	0.0	1
2860	130	0.0	1
2870	130	0.0	1
2880	130	0.0	1
2890	130	0.0	1
2900	130	0.0	1
2910	130	0.0	1
2920	130	0.0	1
2930	130	0.0	1
2940	130	0.0	1
2950	130	0.0	1
2960	130	0.0	1
2970	130	0.0	1
2980	130	0.0	1
2990	130	0.0	1
3000	130	0.0	1
3010	130	0.0	1
3020	130	0.0	1
3030	130	0.0	1
3040	130	0.0	1
3050	130	0.0	1
3060	130	0.0	1
3070	130	0.0	1
3080	130	0.0	1
3090	130	0.0	1
3100	130	0.0	1
3110	130	0.0	1
3120	130	0.0	1
3130	130	0.0	1
3140	130	0.0	1
3150	130	0.0	1
3160	130	0.0	1
3170	130	0.0	1
3180	130	0.0	1
3190	130	0.0	1
3200	130	0.0	1
3210	130	0.0	1
3220	130	0.0	1
3230	130	0.0	1
3240	130	0.0	1
3250	130	0.0	1
3260	130	0.0	1
3270	130	0.0	1
3280	130	0.0	1
3290	130	0.0	1
3300	130		

TABLE 6

Effect of Sensor Separation (SS = 10 km.)

OMEGA =	0	SS = 10000	RAPP =	5000	REDRNG =	.50
VO = 1500.0	VGRAD =	.00050	YDIFF =	.1		
BRGP	BRGB	BRGA	ERROR	BRGT	DELTA	RNGERR
10	1500.48	95.00	16.90	275.00	2	1.48
20	1500.22	100.00	15.00	279.79	2	2.48
30	1501.69	110.00	15.00	283.33	1	5.13
40	1501.22	115.00	12.50	287.21	1	6.34
50	1502.35	120.00	11.00	289.10	1	7.28
60	1502.55	130.00	9.73	290.33	0	8.23
70	1502.53	135.00	8.89	291.00	0	8.89
80	1502.29	140.00	8.89	291.60	0	8.89
90	1502.62	145.00	8.89	292.30	0	8.89
100	1501.62	150.00	11.50	293.00	1	7.65
110	1501.28	155.00	11.50	293.71	1	7.65
120	1501.62	160.00	11.50	294.40	1	7.65
130	1501.28	165.00	11.50	295.10	1	7.65
140	1501.62	170.00	11.50	295.80	1	7.65
150	1500.00	175.00	16.50	296.50	2	8.21
160	1500.00	180.00	16.50	297.20	2	8.21
170	1500.00	185.00	16.50	297.90	2	8.21
180	1499.61	190.00	16.50	298.60	2	8.21
190	1498.74	195.00	15.50	299.30	2	5.92
200	1498.74	200.00	15.50	299.90	2	4.24
210	1498.74	205.00	15.50	300.50	1	5.92
220	1497.86	210.00	15.50	301.10	1	4.24
230	1497.86	215.00	15.50	301.70	1	4.24
240	1497.86	220.00	15.50	302.30	0	4.24
250	1497.86	225.00	15.50	302.90	0	4.24
260	1497.86	230.00	15.50	303.50	0	4.24
270	1497.86	235.00	15.50	304.10	1	4.24
280	1497.86	240.00	15.50	304.70	1	4.24
290	1497.86	245.00	15.50	305.30	1	4.24
300	1497.86	250.00	15.50	305.90	1	4.24
310	1497.86	255.00	15.50	306.50	1	4.24
320	1497.86	260.00	15.50	307.10	1	4.24
330	1497.86	265.00	15.50	307.70	1	4.24
340	1497.86	270.00	15.50	308.30	1	4.24
350	1497.86	275.00	15.50	308.90	1	4.24
360	1497.86	280.00	15.50	309.50	1	4.24
370	1497.86	285.00	15.50	310.10	1	4.24
380	1497.86	290.00	15.50	310.70	1	4.24
390	1497.86	295.00	15.50	311.30	1	4.24
400	1497.86	300.00	15.50	311.90	1	4.24
410	1497.86	305.00	15.50	312.50	1	4.24
420	1497.86	310.00	15.50	313.10	1	4.24
430	1497.86	315.00	15.50	313.70	1	4.24
440	1497.86	320.00	15.50	314.30	1	4.24
450	1497.86	325.00	15.50	314.90	1	4.24
460	1497.86	330.00	15.50	315.50	1	4.24
470	1497.86	335.00	15.50	316.10	1	4.24
480	1497.86	340.00	15.50	316.70	1	4.24
490	1497.86	345.00	15.50	317.30	1	4.24
500	1497.86	350.00	15.50	317.90	1	4.24
510	1497.86	355.00	15.50	318.50	1	4.24
520	1497.86	360.00	15.50	319.10	1	4.24
530	1497.86	365.00	15.50	319.70	1	4.24
540	1497.86	370.00	15.50	320.30	1	4.24
550	1497.86	375.00	15.50	320.90	1	4.24
560	1497.86	380.00	15.50	321.50	1	4.24
570	1497.86	385.00	15.50	322.10	1	4.24
580	1497.86	390.00	15.50	322.70	1	4.24
590	1497.86	395.00	15.50	323.30	1	4.24
600	1497.86	400.00	15.50	323.90	1	4.24
610	1497.86	405.00	15.50	324.50	1	4.24
620	1497.86	410.00	15.50	325.10	1	4.24
630	1497.86	415.00	15.50	325.70	1	4.24
640	1497.86	420.00	15.50	326.30	1	4.24
650	1497.86	425.00	15.50	326.90	1	4.24
660	1497.86	430.00	15.50	327.50	1	4.24
670	1497.86	435.00	15.50	328.10	1	4.24
680	1497.86	440.00	15.50	328.70	1	4.24
690	1497.86	445.00	15.50	329.30	1	4.24
700	1497.86	450.00	15.50	329.90	1	4.24
710	1497.86	455.00	15.50	330.50	1	4.24
720	1497.86	460.00	15.50	331.10	1	4.24
730	1497.86	465.00	15.50	331.70	1	4.24
740	1497.86	470.00	15.50	332.30	1	4.24
750	1497.86	475.00	15.50	332.90	1	4.24
760	1497.86	480.00	15.50	333.50	1	4.24
770	1497.86	485.00	15.50	334.10	1	4.24
780	1497.86	490.00	15.50	334.70	1	4.24
790	1497.86	495.00	15.50	335.30	1	4.24
800	1497.86	500.00	15.50	335.90	1	4.24
810	1497.86	505.00	15.50	336.50	1	4.24
820	1497.86	510.00	15.50	337.10	1	4.24
830	1497.86	515.00	15.50	337.70	1	4.24
840	1497.86	520.00	15.50	338.30	1	4.24
850	1497.86	525.00	15.50	338.90	1	4.24
860	1497.86	530.00	15.50	339.50	1	4.24
870	1497.86	535.00	15.50	340.10	1	4.24
880	1497.86	540.00	15.50	340.70	1	4.24
890	1497.86	545.00	15.50	341.30	1	4.24
900	1497.86	550.00	15.50	341.90	1	4.24
910	1497.86	555.00	15.50	342.50	1	4.24
920	1497.86	560.00	15.50	343.10	1	4.24
930	1497.86	565.00	15.50	343.70	1	4.24
940	1497.86	570.00	15.50	344.30	1	4.24
950	1497.86	575.00	15.50	344.90	1	4.24
960	1497.86	580.00	15.50	345.50	1	4.24
970	1497.86	585.00	15.50	346.10	1	4.24
980	1497.86	590.00	15.50	346.70	1	4.24
990	1497.86	595.00	15.50	347.30	1	4.24
1000	1497.86	600.00	15.50	347.90	1	4.24

TABLE 7

Effect of Sensor Separation (SS = 100 km.)

[illegible]

TABLE 8

Effect of Sensor Separation (SS = 400 km.)

OMEGA = 0		SS = 400000		RAPP = 500000		REDRNG = 1.25	
V0 = 1500.0		VGRAD = .00010		YDIFF = .1			
BRGP	BRGA	BRGB	ERROR	BRGT	DELTA	RNGERR	RELE
10	1506.5	17.1	565	198.1	1.3	705	321
20	1514.2	14.1	609	151.9	1.3	557	963
30	1523.0	28.3	640	234.6	1.1	531	050
40	1533.6	36.3	681	467.3	1.1	425	026
50	1544.5	45.1	723	661.2	1.1	287	018
60	1554.8	55.9	785	772.0	1.1	197	009
70	1564.9	67.8	861	877.0	1.1	133	001
80	1574.8	78.6	935	972.0	1.1	96	000
90	1584.5	89.6	1025	1068.3	1.1	68	000
100	1594.2	101.9	1124	1166.8	1.1	42	000
110	1603.6	113.3	1243	1268.2	1.1	25	000
120	1612.8	125.7	1380	1372.9	1.1	17	000
130	1621.7	138.3	1535	1480.8	1.1	11	000
140	1630.3	151.1	1716	1591.3	1.1	7	000
150	1638.7	165.1	1925	1704.4	1.1	5	000
160	1646.9	179.5	2165	1820.2	1.1	3	000
170	1654.8	194.3	2438	1938.9	1.1	2	000
180	1662.5	209.6	2745	2060.2	1.1	1	000
190	1669.9	225.4	3088	2184.1	1.1	1	000
200	1677.0	241.7	3468	2310.5	1.1	1	000
210	1683.8	258.4	3885	2439.2	1.1	1	000
220	1690.3	275.6	4339	2570.2	1.1	1	000
230	1696.5	293.3	4831	2703.5	1.1	1	000
240	1702.4	311.5	5361	2839.1	1.1	1	000
250	1708.0	330.2	5930	2977.0	1.1	1	000
260	1713.3	349.4	6548	3117.2	1.1	1	000
270	1718.3	369.1	7215	3259.7	1.1	1	000
280	1723.0	389.3	7931	3404.5	1.1	1	000
290	1727.4	409.9	8696	3551.8	1.1	1	000
300	1731.5	431.1	9511	3701.6	1.1	1	000
310	1735.3	452.8	10376	3853.9	1.1	1	000
320	1738.8	475.0	11291	4008.6	1.1	1	000
330	1742.0	497.7	12256	4165.8	1.1	1	000
340	1744.9	520.9	13271	4325.5	1.1	1	000
350	1747.5	544.5	14336	4487.7	1.1	1	000
360	1749.8	568.6	15451	4652.4	1.1	1	000
370	1751.8	593.1	16616	4819.6	1.1	1	000
380	1753.5	618.1	17831	4989.3	1.1	1	000
390	1754.9	643.5	19096	5161.5	1.1	1	000
400	1756.0	669.3	20411	5336.2	1.1	1	000
410	1756.8	695.5	21776	5513.4	1.1	1	000
420	1757.3	722.1	23191	5693.1	1.1	1	000
430	1757.5	749.2	24656	5875.3	1.1	1	000
440	1757.4	776.7	26171	6059.9	1.1	1	000
450	1757.0	804.6	27736	6247.0	1.1	1	000
460	1756.3	832.9	29351	6436.6	1.1	1	000
470	1755.3	861.5	31016	6628.6	1.1	1	000
480	1754.0	890.5	32731	6822.9	1.1	1	000
490	1752.4	919.9	34496	7019.4	1.1	1	000
500	1750.5	949.7	36311	7218.0	1.1	1	000
510	1748.3	979.9	38176	7418.7	1.1	1	000
520	1745.8	1010.5	40091	7621.4	1.1	1	000
530	1743.0	1041.5	42056	7826.1	1.1	1	000
540	1739.9	1072.9	44071	8032.8	1.1	1	000
550	1736.5	1104.7	46136	8241.4	1.1	1	000
560	1732.8	1136.9	48251	8451.9	1.1	1	000
570	1728.8	1169.5	50416	8664.4	1.1	1	000
580	1724.5	1202.5	52631	8878.8	1.1	1	000
590	1719.8	1235.9	54896	9095.1	1.1	1	000
600	1714.8	1269.7	57211	9313.2	1.1	1	000
610	1709.4	1303.9	59576	9533.1	1.1	1	000
620	1703.6	1338.5	61991	9754.7	1.1	1	000
630	1697.4	1373.5	64456	9978.0	1.1	1	000
640	1690.8	1408.9	66971	10212.9	1.1	1	000
650	1683.8	1444.7	69536	10449.4	1.1	1	000
660	1676.4	1480.9	72151	10687.5	1.1	1	000
670	1668.6	1517.5	74816	10927.2	1.1	1	000
680	1660.4	1554.5	77531	11168.4	1.1	1	000
690	1651.8	1591.9	80296	11411.1	1.1	1	000
700	1642.8	1629.7	83111	11655.3	1.1	1	000
710	1633.4	1667.9	85976	11900.9	1.1	1	000
720	1623.6	1706.5	88891	12147.9	1.1	1	000
730	1613.4	1745.5	91856	12396.2	1.1	1	000
740	1602.8	1784.9	94871	12645.8	1.1	1	000
750	1591.8	1824.7	97936	12896.7	1.1	1	000
760	1580.4	1864.9	101051	13148.9	1.1	1	000
770	1568.6	1905.5	104216	13402.4	1.1	1	000
780	1556.4	1946.5	107431	13657.2	1.1	1	000
790	1543.8	1987.9	110696	13913.3	1.1	1	000
800	1530.8	2029.7	114011	14170.6	1.1	1	000
810	1517.4	2071.9	117376	14429.1	1.1	1	000
820	1503.6	2114.5	120791	14688.7	1.1	1	000
830	1489.4	2157.5	124256	14949.4	1.1	1	000
840	1474.8	2200.9	127771	15211.2	1.1	1	000
850	1459.8	2244.7	131336	15474.1	1.1	1	000
860	1444.4	2288.9	134951	15738.1	1.1	1	000
870	1428.6	2333.5	138616	16003.2	1.1	1	000
880	1412.4	2378.5	142331	16269.4	1.1	1	000
890	1395.8	2423.9	146096	16536.7	1.1	1	000
900	1378.8	2469.7	149911	16805.1	1.1	1	000
910	1361.4	2515.9	153776	17074.5	1.1	1	000
920	1343.6	2562.5	157691	17344.9	1.1	1	000
930	1325.4	2609.5	161656	17616.4	1.1	1	000
940	1306.8	2656.9	165671	17888.9	1.1	1	000
950	1287.8	2704.7	169736	18162.4	1.1	1	000
960	1268.4	2752.9	173851	18436.9	1.1	1	000
970	1248.6	2801.5	177916	18712.4	1.1	1	000
980	1228.4	2850.5	182031	18988.9	1.1	1	000
990	1207.8	2899.9	186196	19266.4	1.1	1	000
1000	1186.8	2949.7	190411	19545.1	1.1	1	000

TABLE 9

Effect of Target Range (RAPP = 1 km.)

OMEGA = 0		SS = 1000		RAPP = 1000		REDRNG = 1.00	
VO = 1500.0		VGRAD = .00050		YDIFF = .1			
BRGP	RACT	V2	BRGA	BRGB	ERROR	BRGT	DELTA
10	999	1500.1	19.7	6.7	1.5	201.3	0.0
20	999	1500.2	37.9	13.4	.5	223.9	0.0
30	1000	1500.3	53.5	20.1	.4	237.9	0.0
40	1000	1500.4	67.4	26.8	.3	251.8	0.0
50	1000	1500.5	79.0	33.9	.2	262.5	0.0
60	1000	1500.6	90.5	40.9	.2	270.0	0.0
70	1000	1500.7	99.3	48.1	.2	272.8	0.0
80	1000	1500.8	108.6	55.6	.2	264.1	0.0
90	1000	1500.9	116.4	63.7	.2	251.3	0.0
100	1000	1500.0	123.9	71.8	.2	228.5	0.0
110	1000	1500.1	131.2	80.0	.2	201.3	0.0
120	1000	1500.2	139.1	90.6	.2	177.7	0.0
130	1000	1500.3	146.6	100.5	.3	148.4	0.0
140	1000	1500.4	153.9	112.6	.4	118.8	0.0
150	1000	1500.5	161.3	126.0	.5	80.4	0.0
160	999	1500.6	173.7	140.3	.4	33.8	0.0
170	999	1500.7	186.4	159.7	1.5	1.3	0.0
180	1002	1499.8	199.7	199.7	1.5	0.0	0.0
190	1001	1499.7	206.1	177.9	.6	20.0	0.0
200	1000	1499.6	213.0	143.7	.4	231.0	0.0
210	1000	1499.5	220.8	107.9	.4	255.0	0.0
220	1000	1499.4	228.5	70.0	.3	262.1	0.0
230	1000	1499.3	235.4	28.6	.3	253.6	0.0
240	1000	1499.2	241.5	0.4	.3	222.5	0.0
250	1000	1499.1	246.0	1.9	.4	177.0	0.0
260	1000	1499.0	250.2	6.3	.4	88.2	0.0
270	1000	1499.0	253.5	19.6	.4	30.1	0.0
280	1000	1499.0	256.0	33.9	.6	1.3	0.0
290	1000	1499.0	258.9	46.3	.5	0.0	0.0
300	1001	1499.0	262.0	59.6	1.5	0.0	0.0
310	1001	1499.0	265.3	73.3	1.5	0.0	0.0
320	1001	1499.0	268.9	87.5	1.5	0.0	0.0
330	1001	1499.0	272.9	102.1	1.5	0.0	0.0
340	1001	1499.0	277.0	117.2	1.5	0.0	0.0
350	1001	1499.0	281.3	132.9	1.5	0.0	0.0

TABLE 10

Effect of Target Range (RAPP = 3 km.)

OMEGA = 0	SS = 1000	RAPP = 3000	REDRNG = 3.00	YDIFF = .1	DELTA	RNGERR	RELERR
BRGP							
10					0.0	16.4	0.0
20					0.0	18.5	0.0
30					0.0	15.3	0.0
40					0.0	15.2	0.0
50					0.0	11.7	0.0
60					0.0	11.8	0.0
70					0.0	11.4	0.0
80					0.0	11.5	0.0
90					0.0	11.4	0.0
100					0.0	11.8	0.0
110					0.0	11.7	0.0
120					0.0	12.3	0.0
130					0.0	13.4	0.0
140					0.0	14.8	0.0
150					0.0	16.9	0.0
160					0.0	18.0	0.0
170					0.0	16.4	0.0
180					0.0	16.4	0.0
190					0.0	16.4	0.0
200					0.0	16.4	0.0
210					0.0	16.4	0.0
220					0.0	16.4	0.0
230					0.0	16.4	0.0
240					0.0	16.4	0.0
250					0.0	16.4	0.0
260					0.0	16.4	0.0
270					0.0	16.4	0.0
280					0.0	16.4	0.0
290					0.0	16.4	0.0
300					0.0	16.4	0.0
310					0.0	16.4	0.0
320					0.0	16.4	0.0
330					0.0	16.4	0.0
340					0.0	16.4	0.0
350					0.0	16.4	0.0
360					0.0	16.4	0.0
370					0.0	16.4	0.0
380					0.0	16.4	0.0
390					0.0	16.4	0.0
400					0.0	16.4	0.0
410					0.0	16.4	0.0
420					0.0	16.4	0.0
430					0.0	16.4	0.0
440					0.0	16.4	0.0
450					0.0	16.4	0.0
460					0.0	16.4	0.0
470					0.0	16.4	0.0
480					0.0	16.4	0.0
490					0.0	16.4	0.0
500					0.0	16.4	0.0
510					0.0	16.4	0.0
520					0.0	16.4	0.0
530					0.0	16.4	0.0
540					0.0	16.4	0.0
550					0.0	16.4	0.0
560					0.0	16.4	0.0
570					0.0	16.4	0.0
580					0.0	16.4	0.0
590					0.0	16.4	0.0
600					0.0	16.4	0.0
610					0.0	16.4	0.0
620					0.0	16.4	0.0
630					0.0	16.4	0.0
640					0.0	16.4	0.0
650					0.0	16.4	0.0
660					0.0	16.4	0.0
670					0.0	16.4	0.0
680					0.0	16.4	0.0
690					0.0	16.4	0.0
700					0.0	16.4	0.0
710					0.0	16.4	0.0
720					0.0	16.4	0.0
730					0.0	16.4	0.0
740					0.0	16.4	0.0
750					0.0	16.4	0.0
760					0.0	16.4	0.0
770					0.0	16.4	0.0
780					0.0	16.4	0.0
790					0.0	16.4	0.0
800					0.0	16.4	0.0
810					0.0	16.4	0.0
820					0.0	16.4	0.0
830					0.0	16.4	0.0
840					0.0	16.4	0.0
850					0.0	16.4	0.0
860					0.0	16.4	0.0
870					0.0	16.4	0.0
880					0.0	16.4	0.0
890					0.0	16.4	0.0
900					0.0	16.4	0.0
910					0.0	16.4	0.0
920					0.0	16.4	0.0
930					0.0	16.4	0.0
940					0.0	16.4	0.0
950					0.0	16.4	0.0
960					0.0	16.4	0.0
970					0.0	16.4	0.0
980					0.0	16.4	0.0
990					0.0	16.4	0.0
1000					0.0	16.4	0.0

TABLE 11

Effect of Target Range (RAPP = 100 km.)

OMEGA = 0	SS = 400000	RAPP = 100000	REDRNG = .25	YDIFF = .1
VO = 1500.0	VGRAD = .00010			
BRGP	BRGA	BRGB	ERROR	BRGT
100	170.3	3.6	1320.1	349.1
200	162.1	6.9	650.9	333.0
300	156.2	9.1	450.0	333.3
400	152.0	12.1	349.6	333.3
500	150.0	16.2	284.6	333.3
600	150.0	21.9	236.0	322.9
700	151.5	24.6	199.4	228.6
800	155.3	28.9	174.5	222.2
900	158.0	33.0	164.0	222.2
1000	163.6	39.4	199.0	222.2
1100	166.0	45.8	236.5	222.2
1200	170.0	53.9	284.9	222.2
1300	173.3	63.7	345.0	222.2
1400	176.0	79.7	450.9	222.2
1500	183.3	115.0	650.9	222.2
1600	186.6	155.0	932.0	190.9
1700	189.3	200.5	1320.1	180.0
1800	193.0	256.0	1804.9	180.0
1900	196.0	320.0	2418.0	180.0
2000	199.1	393.0	3274.0	180.0
2100	201.4	477.0	4407.7	180.0
2200	204.6	574.6	5877.8	180.0
2300	208.0	691.9	7757.7	180.0
2400	209.0	829.8	10177.0	180.0
2500	209.3	991.4	13274.2	180.0
2600	209.7	1189.7	18049.9	180.0
2700	210.0	1428.4	24180.2	180.0
2800	210.4	1714.8	32740.2	180.0
2900	210.9	2050.3	44077.2	180.0
3000	211.8	2448.0	58777.2	180.0
3100	212.4	2904.0	77577.2	180.0
3200	214.9	3435.8	101777.2	180.0
3300	219.0	4099.4	132749.9	180.0
3400	223.5	4949.6	180499.9	180.0
3500	228.0	5999.4	241809.9	180.0
3600	233.5	7299.4	327409.9	180.0
3700	239.0	8899.4	440779.9	180.0
3800	245.0	10899.4	587779.9	180.0
3900	251.0	13299.4	775779.9	180.0
4000	258.0	16199.4	101779.9	180.0
4100	265.0	19599.4	132749.9	180.0
4200	273.0	23599.4	180499.9	180.0
4300	281.0	28299.4	241809.9	180.0
4400	290.0	33799.4	327409.9	180.0
4500	299.0	40099.4	440779.9	180.0
4600	309.0	47299.4	587779.9	180.0
4700	319.0	55499.4	775779.9	180.0
4800	330.0	6499.4	101779.9	180.0
4900	341.0	7599.4	132749.9	180.0
5000	353.0	8899.4	180499.9	180.0
5100	366.0	10499.4	241809.9	180.0
5200	380.0	12499.4	327409.9	180.0
5300	395.0	14999.4	440779.9	180.0
5400	411.0	17999.4	587779.9	180.0
5500	428.0	21499.4	775779.9	180.0
5600	446.0	25499.4	101779.9	180.0
5700	465.0	30099.4	132749.9	180.0
5800	486.0	35399.4	180499.9	180.0
5900	508.0	41499.4	241809.9	180.0
6000	532.0	48499.4	327409.9	180.0
6100	558.0	56499.4	440779.9	180.0
6200	586.0	65499.4	587779.9	180.0
6300	616.0	75499.4	775779.9	180.0
6400	648.0	86499.4	101779.9	180.0
6500	682.0	98499.4	132749.9	180.0
6600	718.0	111499.4	180499.9	180.0
6700	756.0	126499.4	241809.9	180.0
6800	796.0	143499.4	327409.9	180.0
6900	838.0	162499.4	440779.9	180.0
7000	882.0	183499.4	587779.9	180.0
7100	928.0	206499.4	775779.9	180.0
7200	976.0	231499.4	101779.9	180.0
7300	1026.0	258499.4	132749.9	180.0
7400	1078.0	287499.4	180499.9	180.0
7500	1132.0	318499.4	241809.9	180.0
7600	1188.0	351499.4	327409.9	180.0
7700	1246.0	386499.4	440779.9	180.0
7800	1306.0	423499.4	587779.9	180.0
7900	1368.0	462499.4	775779.9	180.0
8000	1432.0	503499.4	101779.9	180.0
8100	1498.0	546499.4	132749.9	180.0
8200	1566.0	591499.4	180499.9	180.0
8300	1636.0	638499.4	241809.9	180.0
8400	1708.0	687499.4	327409.9	180.0
8500	1782.0	738499.4	440779.9	180.0
8600	1858.0	791499.4	587779.9	180.0
8700	1936.0	846499.4	775779.9	180.0
8800	2016.0	903499.4	101779.9	180.0
8900	2098.0	962499.4	132749.9	180.0
9000	2182.0	1023499.4	180499.9	180.0
9100	2268.0	1086499.4	241809.9	180.0
9200	2356.0	1151499.4	327409.9	180.0
9300	2446.0	1218499.4	440779.9	180.0
9400	2538.0	1287499.4	587779.9	180.0
9500	2632.0	1358499.4	775779.9	180.0
9600	2728.0	1431499.4	101779.9	180.0
9700	2826.0	1506499.4	132749.9	180.0
9800	2926.0	1583499.4	180499.9	180.0
9900	3028.0	1662499.4	241809.9	180.0
10000	3132.0	1743499.4	327409.9	180.0
10100	3238.0	1826499.4	440779.9	180.0
10200	3346.0	1911499.4	587779.9	180.0
10300	3456.0	1998499.4	775779.9	180.0
10400	3568.0	2087499.4	101779.9	180.0
10500	3682.0	2178499.4	132749.9	180.0
10600	3798.0	2271499.4	180499.9	180.0
10700	3916.0	2366499.4	241809.9	180.0
10800	4036.0	2463499.4	327409.9	180.0
10900	4158.0	2562499.4	440779.9	180.0
11000	4282.0	2663499.4	587779.9	180.0
11100	4408.0	2766499.4	775779.9	180.0
11200	4536.0	2871499.4	101779.9	180.0
11300	4666.0	2978499.4	132749.9	180.0
11400	4798.0	3087499.4	180499.9	180.0
11500	4932.0	3198499.4	241809.9	180.0
11600	5068.0	3311499.4	327409.9	180.0
11700	5206.0	3426499.4	440779.9	180.0
11800	5346.0	3543499.4	587779.9	180.0
11900	5488.0	3662499.4	775779.9	180.0
12000	5632.0	3783499.4	101779.9	180.0
12100	5778.0	3906499.4	132749.9	180.0
12200	5926.0	4031499.4	180499.9	180.0
12300	6076.0	4158499.4	241809.9	180.0
12400	6228.0	4287499.4	327409.9	180.0
12500	6382.0	4418499.4	440779.9	180.0
12600	6538.0	4551499.4	587779.9	180.0
12700	6696.0	4686499.4	775779.9	180.0
12800	6856.0	4823499.4	101779.9	180.0
12900	7018.0	4962499.4	132749.9	180.0
13000	7182.0	5103499.4	180499.9	180.0
13100	7348.0	5246499.4	241809.9	180.0
13200	7516.0	5391499.4	327409.9	180.0
13300	7686.0	5538499.4	440779.9	180.0
13400	7858.0	5687499.4	587779.9	180.0
13500	8032.0	5838499.4	775779.9	180.0
13600	8208.0	5991499.4	101779.9	180.0
13700	8386.0	6146499.4	132749.9	180.0
13800	8566.0	6303499.4	180499.9	180.0
13900	8748.0	6462499.4	241809.9	180.0
14000	8932.0	6623499.4	327409.9	180.0
14100	9118.0	6786499.4	440779.9	180.0
14200	9306.0	6951499.4	587779.9	180.0
14300	9496.0	7118499.4	775779.9	180.0
14400	9688.0	7287499.4	101779.9	180.0
14500	9882.0	7458499.4	132749.9	180.0
14600	10078.0	7631499.4	180499.9	180.0
14700	10276.0	7806499.4	241809.9	180.0
14800	10476.0	7983499.4	327409.9	180.0
14900	10678.0	8162499.4	440779.9	180.0
15000	10882.0	8343499.4	587779.9	180.0
15100	11088.0	8526499.4	775779.9	180.0
15200	11296.0	8711499.4	101779.9	180.0
15300	11506.0	8898499.4	132749.9	180.0
15400	11718.0	9087499.4	180499.9	180.0
15500	11932.0	9278499.4	241809.9	180.0
15600	12148.0	9471499.4	327409.9	180.0
15700	12366.0	9666499.4	440779.9	180.0
15800	12586.0	9863499.4	587779.9	180.0
15900	12808.0	10062499.4	775779.9	180.0
16000	13032.0	10263499.4	101779.9	180.0
16100	13258.0	10466499.4	132749.9	180.0
16200	13486.0	10671499.4	180499.9	180.0
16300	13716.0	10878499.4	241809.9	180.0
16400	13948.0	11087499.4	327409.9	180.0
16500	14182.0	11298499.4	440779.9	180.0
16600	14418.0	11511499.4	587779.9	180.0
16700	14656.0	11726499.4	775779.9	180.0
16800	14896.0	11943499.4	101779.9	180.0
16900	15138.0	12162499.4	132749.9	180.0
17000	15382.0	12383499.4	180499.9	180.0
17100	15628.0	12606499.4	241809.9	180.0
17200	15876.0	12831499.4	327409.9	180.0
17300	16126.0	13058499.4	440779.9	180.0
17400	16378.0	13287499.4	587779.9	180.0
17500	16632.0	13518499.4	775779.9	180.0
17600	16888.0	13751499.4	101779.9	180.0
17700	17146.0	13986499.4	132749.9	180.0
17800	17406.0	14223499.4	180499.9	180.0
17900	17668.0	14462499.4	241809.9	180.0
18000	17932.0	14703499.4	327409.9	180.0
18100	18198.0	14946499.4	440779.9	180.0
18200	18466.0	15191499.4	587779.9	180.0
18300	18736.0	15438499.4	775779.9	180.0
18400	19008.0	15687499.4	101779.9	180.0
18500	19282.0	15938499.4	132749.9	180.0
18600	19558.0	16191499.4	180499.9	180.0
18700	19836.0	16446499.4	241809.9	180.0
18800	20116.0	16703499.4	327409.9	180.0
18900	20398.0	16962499.4	440779.9	180.0
19000	20682.0	17223499.4	587779.9	180.0
19100	20968.0	17486499.4	775779.9	180.0
19200	21256.0	17751499.4	101779.9	180.0
19300	21546.0	18018499.4	132749.9	180.0
19400	21838.0	18287499.4	180499.9	180.0
19500	22132.0	18558499.4	241809.9	180.0
1960				

TABLE 12

Effect of Target Range (RAPP = 1,000 km.)

OMEGA = 0		SS = 400000		RAPP = 1000000		REDRNG = 2.50	
VO = 1500.0		VGRAD = .00010		YDIFF = .1			
BRGP	ACT	V2	BRGA	BRGB	ERROR	DEGT	DELTA
10	33539	1510.6	5.8	3.7	1578	5.8	1.6
20	33539	1522.6	12.4	16.3	2833	9.4	1.1
30	33539	1547.7	23.6	33.2	5546	18.0	1.1
40	33539	1557.0	48.0	63.1	1101	30.7	1.1
50	33539	1581.0	70.9	91.0	1758	40.7	1.1
60	33539	1590.5	91.4	102.7	2453	47.3	1.1
70	33539	1595.0	110.9	127.5	3375	54.7	1.1
80	33539	1599.0	128.7	141.2	4458	61.4	1.1
90	33539	1599.0	146.3	157.5	5757	68.2	1.1
100	33539	1599.0	167.7	177.5	7275	75.1	1.1
110	33539	1599.0	187.4	194.1	8908	81.8	1.1
120	33539	1599.0	207.4	209.0	10646	88.6	1.1
130	33539	1599.0	227.4	224.5	12533	95.5	1.1
140	33539	1599.0	247.4	241.2	14533	102.5	1.1
150	33539	1599.0	267.4	257.5	16757	109.5	1.1
160	33539	1599.0	287.4	272.5	19275	116.5	1.1
170	33539	1599.0	307.4	287.5	22088	123.5	1.1
180	33539	1599.0	327.4	302.5	25188	130.5	1.1
190	33539	1599.0	347.4	317.5	28575	137.5	1.1
200	33539	1599.0	367.4	332.5	32288	144.5	1.1
210	33539	1599.0	387.4	347.5	36388	151.5	1.1
220	33539	1599.0	407.4	362.5	40888	158.5	1.1
230	33539	1599.0	427.4	377.5	45788	165.5	1.1
240	33539	1599.0	447.4	392.5	51088	172.5	1.1
250	33539	1599.0	467.4	407.5	56888	179.5	1.1
260	33539	1599.0	487.4	422.5	63188	186.5	1.1
270	33539	1599.0	507.4	437.5	69988	193.5	1.1
280	33539	1599.0	527.4	452.5	77288	200.5	1.1
290	33539	1599.0	547.4	467.5	85088	207.5	1.1
300	33539	1599.0	567.4	482.5	93488	214.5	1.1
310	33539	1599.0	587.4	497.5	102488	221.5	1.1
320	33539	1599.0	607.4	512.5	112088	228.5	1.1
330	33539	1599.0	627.4	527.5	122288	235.5	1.1
340	33539	1599.0	647.4	542.5	133088	242.5	1.1
350	33539	1599.0	667.4	557.5	144488	249.5	1.1
360	33539	1599.0	687.4	572.5	156488	256.5	1.1
370	33539	1599.0	707.4	587.5	169088	263.5	1.1
380	33539	1599.0	727.4	602.5	182288	270.5	1.1
390	33539	1599.0	747.4	617.5	196088	277.5	1.1
400	33539	1599.0	767.4	632.5	210488	284.5	1.1
410	33539	1599.0	787.4	647.5	225488	291.5	1.1
420	33539	1599.0	807.4	662.5	241088	298.5	1.1
430	33539	1599.0	827.4	677.5	257288	305.5	1.1
440	33539	1599.0	847.4	692.5	274088	312.5	1.1
450	33539	1599.0	867.4	707.5	291488	319.5	1.1
460	33539	1599.0	887.4	722.5	309488	326.5	1.1
470	33539	1599.0	907.4	737.5	328088	333.5	1.1
480	33539	1599.0	927.4	752.5	347288	340.5	1.1
490	33539	1599.0	947.4	767.5	367088	347.5	1.1
500	33539	1599.0	967.4	782.5	387488	354.5	1.1
510	33539	1599.0	987.4	797.5	408488	361.5	1.1
520	33539	1599.0	1007.4	812.5	429988	368.5	1.1
530	33539	1599.0	1027.4	827.5	452088	375.5	1.1
540	33539	1599.0	1047.4	842.5	474788	382.5	1.1
550	33539	1599.0	1067.4	857.5	498088	389.5	1.1
560	33539	1599.0	1087.4	872.5	521988	396.5	1.1
570	33539	1599.0	1107.4	887.5	546488	403.5	1.1
580	33539	1599.0	1127.4	902.5	571588	410.5	1.1
590	33539	1599.0	1147.4	917.5	597288	417.5	1.1
600	33539	1599.0	1167.4	932.5	623588	424.5	1.1
610	33539	1599.0	1187.4	947.5	650488	431.5	1.1
620	33539	1599.0	1207.4	962.5	677988	438.5	1.1
630	33539	1599.0	1227.4	977.5	706088	445.5	1.1
640	33539	1599.0	1247.4	992.5	734788	452.5	1.1
650	33539	1599.0	1267.4	1007.5	764088	459.5	1.1
660	33539	1599.0	1287.4	1022.5	794088	466.5	1.1
670	33539	1599.0	1307.4	1037.5	824788	473.5	1.1
680	33539	1599.0	1327.4	1052.5	856088	480.5	1.1
690	33539	1599.0	1347.4	1067.5	888088	487.5	1.1
700	33539	1599.0	1367.4	1082.5	920788	494.5	1.1
710	33539	1599.0	1387.4	1097.5	954088	501.5	1.1
720	33539	1599.0	1407.4	1112.5	988088	508.5	1.1
730	33539	1599.0	1427.4	1127.5	1022888	515.5	1.1
740	33539	1599.0	1447.4	1142.5	1058388	522.5	1.1
750	33539	1599.0	1467.4	1157.5	1094488	529.5	1.1
760	33539	1599.0	1487.4	1172.5	1131188	536.5	1.1
770	33539	1599.0	1507.4	1187.5	1168488	543.5	1.1
780	33539	1599.0	1527.4	1202.5	1206388	550.5	1.1
790	33539	1599.0	1547.4	1217.5	1244888	557.5	1.1
800	33539	1599.0	1567.4	1232.5	1283988	564.5	1.1
810	33539	1599.0	1587.4	1247.5	1323688	571.5	1.1
820	33539	1599.0	1607.4	1262.5	1363988	578.5	1.1
830	33539	1599.0	1627.4	1277.5	1404888	585.5	1.1
840	33539	1599.0	1647.4	1292.5	1446388	592.5	1.1
850	33539	1599.0	1667.4	1307.5	1488488	599.5	1.1
860	33539	1599.0	1687.4	1322.5	1531188	606.5	1.1
870	33539	1599.0	1707.4	1337.5	1574488	613.5	1.1
880	33539	1599.0	1727.4	1352.5	1618388	620.5	1.1
890	33539	1599.0	1747.4	1367.5	1662888	627.5	1.1
900	33539	1599.0	1767.4	1382.5	1707988	634.5	1.1
910	33539	1599.0	1787.4	1397.5	1753688	641.5	1.1
920	33539	1599.0	1807.4	1412.5	1799988	648.5	1.1
930	33539	1599.0	1827.4	1427.5	1846888	655.5	1.1
940	33539	1599.0	1847.4	1442.5	1894388	662.5	1.1
950	33539	1599.0	1867.4	1457.5	1942488	669.5	1.1
960	33539	1599.0	1887.4	1472.5	1991188	676.5	1.1
970	33539	1599.0	1907.4	1487.5	2040488	683.5	1.1
980	33539	1599.0	1927.4	1502.5	2090388	690.5	1.1
990	33539	1599.0	1947.4	1517.5	2140888	697.5	1.1
1000	33539	1599.0	1967.4	1532.5	2191988	704.5	1.1

TABLE 13

Effect of Target Range (RAPP = 2,000 km.)

OMEGA = 0		SS = 400000		RAPP = 2000000		REDRNG = 5.00	
VO = 1500.0		VGRAD = .000010		YDIFF = .1			
BRGP	BRGA	BRGB	ERROR	BRGT	DELTA	RNGERR	RELEERR
10	11448	11448	11448	193159	22222	85532	42691
20	11448	11448	11448	207159	22222	85532	42691
30	11448	11448	11448	223558	22222	85532	42691
40	11448	11448	11448	235586	22222	85532	42691
50	11448	11448	11448	245869	22222	85532	42691
60	11448	11448	11448	256904	22222	85532	42691
70	11448	11448	11448	269040	22222	85532	42691
80	11448	11448	11448	270404	22222	85532	42691
90	11448	11448	11448	277483	22222	85532	42691
100	11448	11448	11448	281483	22222	85532	42691
110	11448	11448	11448	289483	22222	85532	42691
120	11448	11448	11448	290483	22222	85532	42691
130	11448	11448	11448	294831	22222	85532	42691
140	11448	11448	11448	304831	22222	85532	42691
150	11448	11448	11448	318315	22222	85532	42691
160	11448	11448	11448	334269	22222	85532	42691
170	11448	11448	11448	353789	22222	85532	42691
180	11448	11448	11448	3789180	22222	85532	42691
190	11448	11448	11448	409222	22222	85532	42691
200	11448	11448	11448	449122	22222	85532	42691
210	11448	11448	11448	495555	22222	85532	42691
220	11448	11448	11448	548669	22222	85532	42691
230	11448	11448	11448	608669	22222	85532	42691
240	11448	11448	11448	677031	22222	85532	42691
250	11448	11448	11448	753333	22222	85532	42691
260	11448	11448	11448	838669	22222	85532	42691
270	11448	11448	11448	933333	22222	85532	42691
280	11448	11448	11448	1038669	22222	85532	42691
290	11448	11448	11448	1153333	22222	85532	42691
300	11448	11448	11448	128669	22222	85532	42691
310	11448	11448	11448	143333	22222	85532	42691
320	11448	11448	11448	159669	22222	85532	42691
330	11448	11448	11448	177333	22222	85532	42691
340	11448	11448	11448	197333	22222	85532	42691
350	11448	11448	11448	219669	22222	85532	42691
360	11448	11448	11448	244333	22222	85532	42691
370	11448	11448	11448	271669	22222	85532	42691
380	11448	11448	11448	301669	22222	85532	42691
390	11448	11448	11448	334333	22222	85532	42691
400	11448	11448	11448	369669	22222	85532	42691
410	11448	11448	11448	407333	22222	85532	42691
420	11448	11448	11448	447669	22222	85532	42691
430	11448	11448	11448	490333	22222	85532	42691
440	11448	11448	11448	536669	22222	85532	42691
450	11448	11448	11448	586669	22222	85532	42691
460	11448	11448	11448	640333	22222	85532	42691
470	11448	11448	11448	697669	22222	85532	42691
480	11448	11448	11448	758333	22222	85532	42691
490	11448	11448	11448	823669	22222	85532	42691
500	11448	11448	11448	893333	22222	85532	42691
510	11448	11448	11448	967669	22222	85532	42691
520	11448	11448	11448	104669	22222	85532	42691
530	11448	11448	11448	113333	22222	85532	42691
540	11448	11448	11448	122669	22222	85532	42691
550	11448	11448	11448	132333	22222	85532	42691
560	11448	11448	11448	142669	22222	85532	42691
570	11448	11448	11448	153333	22222	85532	42691
580	11448	11448	11448	164669	22222	85532	42691
590	11448	11448	11448	176333	22222	85532	42691
600	11448	11448	11448	188669	22222	85532	42691
610	11448	11448	11448	201669	22222	85532	42691
620	11448	11448	11448	215333	22222	85532	42691
630	11448	11448	11448	229669	22222	85532	42691
640	11448	11448	11448	244333	22222	85532	42691
650	11448	11448	11448	259669	22222	85532	42691
660	11448	11448	11448	275333	22222	85532	42691
670	11448	11448	11448	291669	22222	85532	42691
680	11448	11448	11448	308333	22222	85532	42691
690	11448	11448	11448	325669	22222	85532	42691
700	11448	11448	11448	343333	22222	85532	42691
710	11448	11448	11448	361669	22222	85532	42691
720	11448	11448	11448	380333	22222	85532	42691
730	11448	11448	11448	399669	22222	85532	42691
740	11448	11448	11448	419333	22222	85532	42691
750	11448	11448	11448	439669	22222	85532	42691
760	11448	11448	11448	460333	22222	85532	42691
770	11448	11448	11448	481669	22222	85532	42691
780	11448	11448	11448	503333	22222	85532	42691
790	11448	11448	11448	525669	22222	85532	42691
800	11448	11448	11448	548333	22222	85532	42691
810	11448	11448	11448	571669	22222	85532	42691
820	11448	11448	11448	595333	22222	85532	42691
830	11448	11448	11448	619669	22222	85532	42691
840	11448	11448	11448	644333	22222	85532	42691
850	11448	11448	11448	669669	22222	85532	42691
860	11448	11448	11448	695333	22222	85532	42691
870	11448	11448	11448	721669	22222	85532	42691
880	11448	11448	11448	748333	22222	85532	42691
890	11448	11448	11448	775669	22222	85532	42691
900	11448	11448	11448	803333	22222	85532	42691
910	11448	11448	11448	831669	22222	85532	42691
920	11448	11448	11448	860333	22222	85532	42691
930	11448	11448	11448	889669	22222	85532	42691
940	11448	11448	11448	919333	22222	85532	42691
950	11448	11448	11448	949669	22222	85532	42691
960	11448	11448	11448	980333	22222	85532	42691
970	11448	11448	11448	1011669	22222	85532	42691
980	11448	11448	11448	1040333	22222	85532	42691
990	11448	11448	11448	1069669	22222	85532	42691
1000	11448	11448	11448	1099333	22222	85532	42691

TABLE 14

Effect of Sensor Axis Orientation ($\text{OMEGA} = 0^\circ$)

OMEGA = 0	SS = 2000	RAPP = .00050	VGRAD = .00050	FIX(BRG)=180	YDIFF = .1	REDRNG = 3.00
BRGP	BRGA	BRGB	ERROR	DEG	DELTA	RNGERR
100	120	180	65.6	195.5	1	5.0
200	125	175	32.1	105.5	1	3.0
300	135	205	15.3	225.5	1	2.0
400	145	225	7.7	350.5	0	1.5
500	150	235	3.7	50.5	0	1.0
600	150	245	2.5	66.5	0	0.8
700	150	250	4.0	77.6	0	0.7
800	150	253	5.4	89.0	0	0.6
900	150	255	6.4	99.1	0	0.5
1000	150	256	7.5	109.4	0	0.4
1100	150	257	8.4	118.6	0	0.3
1200	150	258	9.0	126.6	0	0.2
1300	150	259	9.5	134.4	0	0.1
1400	150	260	9.9	142.0	0	0.1
1500	150	261	10.2	149.5	0	0.1
1600	150	262	10.4	156.8	0	0.1
1700	150	263	10.5	164.0	0	0.1
1800	150	264	10.5	171.0	0	0.1
1900	150	265	10.5	177.9	0	0.1
2000	150	266	10.5	184.9	0	0.1
2100	150	267	10.5	191.9	0	0.1
2200	150	268	10.5	198.9	0	0.1
2300	150	269	10.5	205.9	0	0.1
2400	150	270	10.5	212.9	0	0.1
2500	150	271	10.5	219.9	0	0.1
2600	150	272	10.5	226.9	0	0.1
2700	150	273	10.5	233.9	0	0.1
2800	150	274	10.5	240.9	0	0.1
2900	150	275	10.5	247.9	0	0.1
3000	150	276	10.5	254.9	0	0.1
3100	150	277	10.5	261.9	0	0.1
3200	150	278	10.5	268.9	0	0.1
3300	150	279	10.5	275.9	0	0.1
3400	150	280	10.5	282.9	0	0.1
3500	150	281	10.5	289.9	0	0.1
3600	150	282	10.5	296.9	0	0.1
3700	150	283	10.5	303.9	0	0.1
3800	150	284	10.5	310.9	0	0.1
3900	150	285	10.5	317.9	0	0.1
4000	150	286	10.5	324.9	0	0.1
4100	150	287	10.5	331.9	0	0.1
4200	150	288	10.5	338.9	0	0.1
4300	150	289	10.5	345.9	0	0.1
4400	150	290	10.5	352.9	0	0.1
4500	150	291	10.5	359.9	0	0.1
4600	150	292	10.5	366.9	0	0.1
4700	150	293	10.5	373.9	0	0.1
4800	150	294	10.5	380.9	0	0.1
4900	150	295	10.5	387.9	0	0.1
5000	150	296	10.5	394.9	0	0.1
5100	150	297	10.5	401.9	0	0.1
5200	150	298	10.5	408.9	0	0.1
5300	150	299	10.5	415.9	0	0.1
5400	150	300	10.5	422.9	0	0.1
5500	150	301	10.5	429.9	0	0.1
5600	150	302	10.5	436.9	0	0.1
5700	150	303	10.5	443.9	0	0.1
5800	150	304	10.5	450.9	0	0.1
5900	150	305	10.5	457.9	0	0.1
6000	150	306	10.5	464.9	0	0.1
6100	150	307	10.5	471.9	0	0.1
6200	150	308	10.5	478.9	0	0.1
6300	150	309	10.5	485.9	0	0.1
6400	150	310	10.5	492.9	0	0.1
6500	150	311	10.5	500.0	0	0.1
6600	150	312	10.5	507.0	0	0.1
6700	150	313	10.5	514.0	0	0.1
6800	150	314	10.5	521.0	0	0.1
6900	150	315	10.5	528.0	0	0.1
7000	150	316	10.5	535.0	0	0.1
7100	150	317	10.5	542.0	0	0.1
7200	150	318	10.5	549.0	0	0.1
7300	150	319	10.5	556.0	0	0.1
7400	150	320	10.5	563.0	0	0.1
7500	150	321	10.5	570.0	0	0.1
7600	150	322	10.5	577.0	0	0.1
7700	150	323	10.5	584.0	0	0.1
7800	150	324	10.5	591.0	0	0.1
7900	150	325	10.5	598.0	0	0.1
8000	150	326	10.5	605.0	0	0.1
8100	150	327	10.5	612.0	0	0.1
8200	150	328	10.5	619.0	0	0.1
8300	150	329	10.5	626.0	0	0.1
8400	150	330	10.5	633.0	0	0.1
8500	150	331	10.5	640.0	0	0.1
8600	150	332	10.5	647.0	0	0.1
8700	150	333	10.5	654.0	0	0.1
8800	150	334	10.5	661.0	0	0.1
8900	150	335	10.5	668.0	0	0.1
9000	150	336	10.5	675.0	0	0.1
9100	150	337	10.5	682.0	0	0.1
9200	150	338	10.5	689.0	0	0.1
9300	150	339	10.5	696.0	0	0.1
9400	150	340	10.5	703.0	0	0.1
9500	150	341	10.5	710.0	0	0.1
9600	150	342	10.5	717.0	0	0.1
9700	150	343	10.5	724.0	0	0.1
9800	150	344	10.5	731.0	0	0.1
9900	150	345	10.5	738.0	0	0.1
10000	150	346	10.5	745.0	0	0.1
10100	150	347	10.5	752.0	0	0.1
10200	150	348	10.5	759.0	0	0.1
10300	150	349	10.5	766.0	0	0.1
10400	150	350	10.5	773.0	0	0.1
10500	150	351	10.5	780.0	0	0.1
10600	150	352	10.5	787.0	0	0.1
10700	150	353	10.5	794.0	0	0.1
10800	150	354	10.5	801.0	0	0.1
10900	150	355	10.5	808.0	0	0.1
11000	150	356	10.5	815.0	0	0.1
11100	150	357	10.5	822.0	0	0.1
11200	150	358	10.5	829.0	0	0.1
11300	150	359	10.5	836.0	0	0.1
11400	150	360	10.5	843.0	0	0.1
11500	150	361	10.5	850.0	0	0.1
11600	150	362	10.5	857.0	0	0.1
11700	150	363	10.5	864.0	0	0.1
11800	150	364	10.5	871.0	0	0.1
11900	150	365	10.5	878.0	0	0.1
12000	150	366	10.5	885.0	0	0.1
12100	150	367	10.5	892.0	0	0.1
12200	150	368	10.5	899.0	0	0.1
12300	150	369	10.5	906.0	0	0.1
12400	150	370	10.5	913.0	0	0.1
12500	150	371	10.5	920.0	0	0.1
12600	150	372	10.5	927.0	0	0.1
12700	150	373	10.5	934.0	0	0.1
12800	150	374	10.5	941.0	0	0.1
12900	150	375	10.5	948.0	0	0.1
13000	150	376	10.5	955.0	0	0.1
13100	150	377	10.5	962.0	0	0.1
13200	150	378	10.5	969.0	0	0.1
13300	150	379	10.5	976.0	0	0.1
13400	150	380	10.5	983.0	0	0.1
13500	150	381	10.5	990.0	0	0.1
13600	150	382	10.5	997.0	0	0.1
13700	150	383	10.5	1004.0	0	0.1
13800	150	384	10.5	1011.0	0	0.1
13900	150	385	10.5	1018.0	0	0.1
14000	150	386	10.5	1025.0	0	0.1
14100	150	387	10.5	1032.0	0	0.1
14200	150	388	10.5	1039.0	0	0.1
14300	150	389	10.5	1046.0	0	0.1
14400	150	390	10.5	1053.0	0	0.1
14500	150	391	10.5	1060.0	0	0.1
14600	150	392	10.5	1067.0	0	0.1
14700	150	393	10.5	1074.0	0	0.1
14800	150	394	10.5	1081.0	0	0.1
14900	150	395	10.5	1088.0	0	0.1
15000	150	396	10.5	1095.0	0	0.1
15100	150	397	10.5	1102.0	0	0.1
15200	150	398	10.5	1109.0	0	0.1
15300	150	399	10.5	1116.0	0	0.1
15400	150	400	10.5	1123.0	0	0.1
15500	150	401	10.5	1130.0	0	0.1
15600	150	402	10.5	1137.0	0	0.1
15700	150	403	10.5	1144.0	0	0.1
15800	150	404	10.5	1151.0	0	0.1
15900	150	405	10.5	1158.0	0	0.1
16000	150	406	10.5	1165.0	0	0.1
16100	150	407	10.5	1172.0	0	0.1
16200	150	408	10.5	1179.0	0	0.1
16300	150	409	10.5	1186.0	0	0.1
16400	150	410	10.5	1193.0	0	0.1
16500	150	411	10.5	1200.0	0	0.1
16600	150	412	10.5	1207.0	0	0.1
16700	150	413	10.5	1214.0	0	0.1
16800	150	414	10.5	1221.0	0	0.1
16900	150	415	10.5	1228.0	0	0.1
17000	150	416	10.5	1235.0	0	0.1
17100	150	417	10.5	1242.0	0	0.1
17200	150	418	10.5	1249.0	0	0.1
17300	150	419	10.5	1256.0	0	0.1
17400	150	420	10.5	1263.0	0	0.1
17500	150	421	10.5	1270.0	0	0.1
17600	150	422	10.5	1277.0	0	0.1
17700	150	423	10.5	1284.0	0	0.1
17800	150	424	10.5	1291.0	0	0.1
17900	150	425	10.5	1298.0	0	0.1
18000	150	426	10.5	1305.0	0	0.1
18100	150	427	10.5	1312.0	0	0.1
18200	150	428	10.5	1319.0	0	0.1
18300	150	429	10.5	1326.0	0	0.1
18400	150	430	10.5	1333.0	0	0.1
18500	150	431	10.5	1340.0	0	0.1
18600	150	432	10.5	1347.0	0	0.1
18700	150	433	10.5	1354.0	0	0.1
18800	150	434	10.5	1361.0	0	0.1
18900	150	435	10.5	1368.0	0	0.1
19000	150	436	10.5	1375.0	0	0.1
19100	150	437	10.5	1382.0	0	0.1
19200	150	438	10.5	1389.0	0	0.1
19300	150	439	10.5	1396.0	0	0.1
19400	150	440	10.5	1403.0	0	0.1
19500	150	441	10.5	1410.0	0	0.1
19600	150					

APPENDIX III

TABLE 15

Effect of Sensor Axis Orientation (OMEGA = 10°)

OMEGA = 10	SS = 2000	RAPP = 6000	REDRNG = 3.00
V0 = 1500.0	VGRAD = .00050	YDIFF = .1	
BRGP	BRGA	BRGB	ERROR
10	12:09	8:28	63:6
20	23:56	17:54	31:7
30	35:01	25:43	19:1
40	47:01	34:32	10:6
50	58:49	43:21	18:3
60	69:46	51:10	6:6
70	79:51	58:00	6:6
80	89:51	64:50	8:1
90	99:51	70:40	8:1
100	109:51	75:30	8:1
110	117:46	80:20	9:4
120	123:56	84:10	12:0
130	135:01	90:00	12:3
140	144:22	95:50	12:3
150	154:22	101:40	12:3
160	164:22	107:30	12:3
170	174:22	113:20	12:3
180	184:22	119:10	12:3
190	194:22	125:00	12:3
200	204:22	130:50	12:3
210	214:22	136:40	12:3
220	224:22	142:30	12:3
230	234:22	148:20	12:3
240	244:22	154:10	12:3
250	254:22	160:00	12:3
260	264:22	165:50	12:3
270	274:22	171:40	12:3
280	284:22	177:30	12:3
290	294:22	183:20	12:3
300	304:22	189:10	12:3
310	314:22	195:00	12:3
320	324:22	200:50	12:3
330	334:22	206:40	12:3
340	344:22	212:30	12:3
350	354:22	218:20	12:3
360	364:22	224:10	12:3
370	374:22	230:00	12:3
380	384:22	235:50	12:3
390	394:22	241:40	12:3
400	404:22	247:30	12:3
410	414:22	253:20	12:3
420	424:22	259:10	12:3
430	434:22	265:00	12:3
440	444:22	270:50	12:3
450	454:22	276:40	12:3
460	464:22	282:30	12:3
470	474:22	288:20	12:3
480	484:22	294:10	12:3
490	494:22	300:00	12:3
500	504:22	305:50	12:3
510	514:22	311:40	12:3
520	524:22	317:30	12:3
530	534:22	323:20	12:3
540	544:22	329:10	12:3
550	554:22	335:00	12:3
560	564:22	340:50	12:3
570	574:22	346:40	12:3
580	584:22	352:30	12:3
590	594:22	358:20	12:3
600	604:22	364:10	12:3
610	614:22	370:00	12:3
620	624:22	375:50	12:3
630	634:22	381:40	12:3
640	644:22	387:30	12:3
650	654:22	393:20	12:3
660	664:22	399:10	12:3
670	674:22	405:00	12:3
680	684:22	410:50	12:3
690	694:22	416:40	12:3
700	704:22	422:30	12:3
710	714:22	428:20	12:3
720	724:22	434:10	12:3
730	734:22	440:00	12:3
740	744:22	445:50	12:3
750	754:22	451:40	12:3
760	764:22	457:30	12:3
770	774:22	463:20	12:3
780	784:22	469:10	12:3
790	794:22	475:00	12:3
800	804:22	480:50	12:3
810	814:22	486:40	12:3
820	824:22	492:30	12:3
830	834:22	498:20	12:3
840	844:22	504:10	12:3
850	854:22	510:00	12:3
860	864:22	515:50	12:3
870	874:22	521:40	12:3
880	884:22	527:30	12:3
890	894:22	533:20	12:3
900	904:22	539:10	12:3
910	914:22	545:00	12:3
920	924:22	550:50	12:3
930	934:22	556:40	12:3
940	944:22	562:30	12:3
950	954:22	568:20	12:3
960	964:22	574:10	12:3
970	974:22	580:00	12:3
980	984:22	585:50	12:3
990	994:22	591:40	12:3
1000	1004:22	597:30	12:3
1010	1014:22	603:20	12:3
1020	1024:22	609:10	12:3
1030	1034:22	615:00	12:3
1040	1044:22	620:50	12:3
1050	1054:22	626:40	12:3
1060	1064:22	632:30	12:3
1070	1074:22	638:20	12:3
1080	1084:22	644:10	12:3
1090	1094:22	650:00	12:3
1100	1104:22	655:50	12:3
1110	1114:22	661:40	12:3
1120	1124:22	667:30	12:3
1130	1134:22	673:20	12:3
1140	1144:22	679:10	12:3
1150	1154:22	685:00	12:3
1160	1164:22	690:50	12:3
1170	1174:22	696:40	12:3
1180	1184:22	702:30	12:3
1190	1194:22	708:20	12:3
1200	1204:22	714:10	12:3
1210	1214:22	720:00	12:3
1220	1224:22	725:50	12:3
1230	1234:22	731:40	12:3
1240	1244:22	737:30	12:3
1250	1254:22	743:20	12:3
1260	1264:22	749:10	12:3
1270	1274:22	755:00	12:3
1280	1284:22	760:50	12:3
1290	1294:22	766:40	12:3
1300	1304:22	772:30	12:3
1310	1314:22	778:20	12:3
1320	1324:22	784:10	12:3
1330	1334:22	790:00	12:3
1340	1344:22	795:50	12:3
1350	1354:22	801:40	12:3
1360	1364:22	807:30	12:3
1370	1374:22	813:20	12:3
1380	1384:22	819:10	12:3
1390	1394:22	825:00	12:3
1400	1404:22	830:50	12:3
1410	1414:22	836:40	12:3
1420	1424:22	842:30	12:3
1430	1434:22	848:20	12:3
1440	1444:22	854:10	12:3
1450	1454:22	860:00	12:3
1460	1464:22	865:50	12:3
1470	1474:22	871:40	12:3
1480	1484:22	877:30	12:3
1490	1494:22	883:20	12:3
1500	1504:22	889:10	12:3
1510	1514:22	895:00	12:3
1520	1524:22	900:50	12:3
1530	1534:22	906:40	12:3
1540	1544:22	912:30	12:3
1550	1554:22	918:20	12:3
1560	1564:22	924:10	12:3
1570	1574:22	930:00	12:3
1580	1584:22	935:50	12:3
1590	1594:22	941:40	12:3
1600	1604:22	947:30	12:3
1610	1614:22	953:20	12:3
1620	1624:22	959:10	12:3
1630	1634:22	965:00	12:3
1640	1644:22	970:50	12:3
1650	1654:22	976:40	12:3
1660	1664:22	982:30	12:3
1670	1674:22	988:20	12:3
1680	1684:22	994:10	12:3
1690	1694:22	1000:00	12:3
1700	1704:22	1005:50	12:3
1710	1714:22	1011:40	12:3
1720	1724:22	1017:30	12:3
1730	1734:22	1023:20	12:3
1740	1744:22	1029:10	12:3
1750	1754:22	1035:00	12:3
1760	1764:22	1040:50	12:3
1770	1774:22	1046:40	12:3
1780	1784:22	1052:30	12:3
1790	1794:22	1058:20	12:3
1800	1804:22	1064:10	12:3
1810	1814:22	1070:00	12:3
1820	1824:22	1075:50	12:3
1830	1834:22	1081:40	12:3
1840	1844:22	1087:30	12:3
1850	1854:22	1093:20	12:3
1860	1864:22	1099:10	12:3
1870	1874:22	1105:00	12:3
1880	1884:22	1110:50	12:3
1890	1894:22	1116:40	12:3
1900	1904:22	1122:30	12:3
1910	1914:22	1128:20	12:3
1920	1924:22	1134:10	12:3
1930	1934:22	1140:00	12:3
1940	1944:22	1145:50	12:3
1950	1954:22	1151:40	12:3
1960	1964:22	1157:30	12:3
1970	1974:22	1163:20	12:3
1980	1984:22	1169:10	12:3
1990	1994:22	1175:00	12:3
2000	2004:22	1180:50	12:3
2010	2014:22	1186:40	12:3
2020	2024:22	1192:30	12:3
2030	2034:22	1198:20	12:3
2040	2044:22	1204:10	12:3
2050	2054:22	1210:00	12:3
2060	2064:22	1215:50	12:3
2070	2074:22	1221:40	12:3
2080	2084:22	1227:30	12:3
2090	2094:22	1233:20	12:3
2100	2104:22	1239:10	12:3
2110	2114:22	1245:00	12:3
2120	2124:22	1250:50	12:3
2130	2134:22	1256:40	12:3
2140	2144:22	1262:30	12:3
2150	2154:22	1268:20	12:3
2160	2164:22	1274:10	12:3
2170	2174:22	1280:00	12:3
2180	2184:22	1285:50	12:3
2190	2194:22	1291:40	12:3
2200	2204:22	1297:30	12:3
2210	2214:22	1303:20	12:3
2220	2224:22	1309:10	12:3
2230	2234:22	1315:00	12:3
2240	2244:22	1320:50	12:3
2250	2254:22	1326:40	12:3
2260	2264:22	1332:30	12:3
2270	2274:22	1338:20	12:3
2280	2284:22	1344:10	12:3
2290	2294:22	1350:00	12:3
2300	2304:22	1355:50	12:3
2310	2314:22	1361:40	12:3
2320	2324:22	1367:30	12:3
2330	2334:22	1373:20	12:3
2340	2344:22	1379:10	12:3
2350	2354:22	1385:00	12:3
2360	2364:22	1390:50	12:3
2370	2374:22	1396:40	12:3
2380	2384:22	1402:30	12:3
2390	2394:22	1408:20	12:3
2400	2404:22	1414:10	12:3
2410	2414:22	1420:00	12:3
2420	2424:22	1425:50	12:3
2430	2434:22	1431:40	12:3
2440	2444:22	1437:30	12:3
2450	2454:22	1443:20	12:3
2460	2464:22	1449:10	12:3
2470	2474:22	1455:00	12:3
2480	2484:22	1460:50	12:3
2490	2494:22	1466:40	12:3
2500	2504:22	1472:30	12:3
2510	2514:22	1478:20	12:3
2520	2524:22	1484:10	12:3
2530	2534:22	1490:00	12:3
2540	2544:22	1495:50	12:3
2550	2554:22	1501:40	12:3
2560	2564:22	1507:30	12:3
2570	2574:22	1513:20	12:3
2580	2584:22	1519:10	12:3
2590	2594:22	1525:00	12:3
2600	2604:22	1530:50	12:3

TABLE 16

Effect of Sensor Axis Orientation ($\Omega = 20^\circ$)

$\Omega = 20$		$\Omega = 2000$		$\Omega = 6000$		$\Omega = 3.00$	
$V_0 = 1500.0$		$V_{GRAD} = .00050$		$RAPP = .00050$		$YDIFF = .1$	
BRGP	ACT	V2	BRGA	BRGB	ERROR	DEG	BRGT
10	5940	1501.5	12.9	8.2	59.8	195.3	3.1
20	5972	1501.2	13.6	25.8	28.0	223.5	10.5
30	5988	1502.3	37.0	43.4	18.5	244.9	23.4
40	5991	1503.3	58.1	52.6	7.2	250.7	49.8
50	5993	1503.8	79.4	61.6	2.0	259.1	87.9
60	5994	1504.0	99.5	70.9	5.6	267.4	130.5
70	5994	1504.2	118.6	80.4	7.1	272.8	183.3
80	5994	1504.3	136.5	90.6	4.4	284.9	253.7
90	5993	1504.2	154.2	100.1	8.2	293.8	344.4
100	5991	1501.5	171.7	111.9	16.1	303.3	459.1
110	5988	1501.0	187.5	123.3	23.6	314.4	598.4
120	5985	1500.5	197.0	134.4	33.3	327.4	768.3
130	5979	1499.9	205.6	146.0	44.2	342.4	968.4
140	5968	1499.5	217.1	158.0	56.8	359.1	1208.3
150	5936	1499.5	228.6	168.0	71.3	377.4	1498.4
160	6061	1498.5	238.6	178.0	88.1	397.4	1848.3
170	6029	1497.7	244.4	185.6	107.3	419.1	2258.4
180	6012	1497.2	250.0	192.0	129.3	442.5	2748.9
190	6007	1497.0	256.0	195.9	153.7	469.0	3328.4
200	6006	1497.0	260.5	197.5	180.1	499.1	3998.3
210	6006	1497.0	264.0	198.0	209.3	534.1	4768.4
220	6006	1497.0	267.0	198.0	237.4	574.1	5648.3
230	6006	1497.0	270.0	198.0	265.6	619.1	6648.4
240	6006	1497.0	273.0	198.0	293.7	669.1	7848.3
250	6006	1497.0	276.0	198.0	321.9	724.1	9248.4
260	6006	1497.0	279.0	198.0	350.1	784.1	10948.3
270	6006	1497.0	282.0	198.0	378.3	849.1	12948.4
280	6006	1497.0	285.0	198.0	406.5	919.1	15248.3
290	6006	1497.0	288.0	198.0	434.7	994.1	17948.4
300	6006	1497.0	291.0	198.0	462.9	1074.1	21048.3
310	6006	1497.0	294.0	198.0	491.1	1159.1	24548.4
320	6006	1497.0	297.0	198.0	519.3	1249.1	28448.3
330	6006	1497.0	300.0	198.0	547.5	1344.1	32748.4
340	6006	1497.0	303.0	198.0	575.7	1444.1	37448.3
350	6006	1497.0	306.0	198.0	603.9	1549.1	42548.4
360	6006	1497.0	309.0	198.0	632.1	1659.1	48048.3
370	6006	1497.0	312.0	198.0	660.3	1774.1	53948.4
380	6006	1497.0	315.0	198.0	688.5	1894.1	60248.3
390	6006	1497.0	318.0	198.0	716.7	2019.1	67048.4
400	6006	1497.0	321.0	198.0	744.9	2149.1	74248.3
410	6006	1497.0	324.0	198.0	773.1	2284.1	81848.4
420	6006	1497.0	327.0	198.0	801.3	2424.1	90048.3
430	6006	1497.0	330.0	198.0	829.5	2569.1	98848.4
440	6006	1497.0	333.0	198.0	857.7	2719.1	108248.3
450	6006	1497.0	336.0	198.0	885.9	2874.1	118248.4
460	6006	1497.0	339.0	198.0	914.1	3034.1	128848.3
470	6006	1497.0	342.0	198.0	942.3	3199.1	140048.4
480	6006	1497.0	345.0	198.0	970.5	3369.1	151848.3
490	6006	1497.0	348.0	198.0	998.7	3544.1	164248.4
500	6006	1497.0	351.0	198.0	1026.9	3724.1	177248.3
510	6006	1497.0	354.0	198.0	1055.1	3909.1	190848.4
520	6006	1497.0	357.0	198.0	1083.3	4099.1	205048.3
530	6006	1497.0	360.0	198.0	1111.5	4294.1	219848.4
540	6006	1497.0	363.0	198.0	1139.7	4494.1	235248.3
550	6006	1497.0	366.0	198.0	1167.9	4699.1	251248.4
560	6006	1497.0	369.0	198.0	1196.1	4909.1	267848.3
570	6006	1497.0	372.0	198.0	1224.3	5124.1	285048.4
580	6006	1497.0	375.0	198.0	1252.5	5344.1	302848.3
590	6006	1497.0	378.0	198.0	1280.7	5569.1	321248.4
600	6006	1497.0	381.0	198.0	1308.9	5799.1	340248.3
610	6006	1497.0	384.0	198.0	1337.1	6034.1	360848.4
620	6006	1497.0	387.0	198.0	1365.3	6274.1	383048.3
630	6006	1497.0	390.0	198.0	1393.5	6519.1	406848.4
640	6006	1497.0	393.0	198.0	1421.7	6769.1	432248.3
650	6006	1497.0	396.0	198.0	1449.9	7024.1	459248.4
660	6006	1497.0	399.0	198.0	1478.1	7284.1	487848.3
670	6006	1497.0	402.0	198.0	1506.3	7549.1	518048.4
680	6006	1497.0	405.0	198.0	1534.5	7819.1	549848.3
690	6006	1497.0	408.0	198.0	1562.7	8094.1	583248.4
700	6006	1497.0	411.0	198.0	1590.9	8374.1	618248.3
710	6006	1497.0	414.0	198.0	1619.1	8659.1	654848.4
720	6006	1497.0	417.0	198.0	1647.3	8949.1	693048.3
730	6006	1497.0	420.0	198.0	1675.5	9244.1	732848.4
740	6006	1497.0	423.0	198.0	1703.7	9544.1	774248.3
750	6006	1497.0	426.0	198.0	1731.9	9849.1	817248.4
760	6006	1497.0	429.0	198.0	1760.1	10159.1	861848.3
770	6006	1497.0	432.0	198.0	1788.3	10474.1	908048.4
780	6006	1497.0	435.0	198.0	1816.5	10794.1	955848.3
790	6006	1497.0	438.0	198.0	1844.7	11119.1	1005248.4
800	6006	1497.0	441.0	198.0	1872.9	11449.1	1056248.3
810	6006	1497.0	444.0	198.0	1901.1	11784.1	1108848.4
820	6006	1497.0	447.0	198.0	1929.3	12124.1	1163048.3
830	6006	1497.0	450.0	198.0	1957.5	12469.1	1218848.4
840	6006	1497.0	453.0	198.0	1985.7	12819.1	1276248.3
850	6006	1497.0	456.0	198.0	2013.9	13174.1	1335248.4
860	6006	1497.0	459.0	198.0	2042.1	13534.1	1395848.3
870	6006	1497.0	462.0	198.0	2070.3	13899.1	1458048.4
880	6006	1497.0	465.0	198.0	2098.5	14269.1	1521848.3
890	6006	1497.0	468.0	198.0	2126.7	14644.1	1587248.4
900	6006	1497.0	471.0	198.0	2154.9	15024.1	1654248.3
910	6006	1497.0	474.0	198.0	2183.1	15409.1	1722848.4
920	6006	1497.0	477.0	198.0	2211.3	15799.1	1793048.3
930	6006	1497.0	480.0	198.0	2239.5	16194.1	1864848.4
940	6006	1497.0	483.0	198.0	2267.7	16594.1	1938248.3
950	6006	1497.0	486.0	198.0	2295.9	16999.1	2013248.4
960	6006	1497.0	489.0	198.0	2324.1	17409.1	2090848.3
970	6006	1497.0	492.0	198.0	2352.3	17824.1	2170048.4
980	6006	1497.0	495.0	198.0	2380.5	18244.1	2250848.3
990	6006	1497.0	498.0	198.0	2408.7	18669.1	2333248.4
1000	6006	1497.0	501.0	198.0	2436.9	19099.1	2417248.3
1010	6006	1497.0	504.0	198.0	2465.1	19534.1	2502848.4
1020	6006	1497.0	507.0	198.0	2493.3	19974.1	2590048.3
1030	6006	1497.0	510.0	198.0	2521.5	20419.1	2678848.4
1040	6006	1497.0	513.0	198.0	2549.7	20869.1	2769248.3
1050	6006	1497.0	516.0	198.0	2577.9	21324.1	2861248.4
1060	6006	1497.0	519.0	198.0	2606.1	21784.1	2954848.3
1070	6006	1497.0	522.0	198.0	2634.3	22249.1	3050048.4
1080	6006	1497.0	525.0	198.0	2662.5	22719.1	3146848.3
1090	6006	1497.0	528.0	198.0	2690.7	23194.1	3245248.4
1100	6006	1497.0	531.0	198.0	2718.9	23674.1	3345248.3
1110	6006	1497.0	534.0	198.0	2747.1	24159.1	3446848.4
1120	6006	1497.0	537.0	198.0	2775.3	24649.1	3549048.3
1130	6006	1497.0	540.0	198.0	2803.5	25134.1	3652848.4
1140	6006	1497.0	543.0	198.0	2831.7	25624.1	3758248.3
1150	6006	1497.0	546.0	198.0	2859.9	26119.1	3865248.4
1160	6006	1497.0	549.0	198.0	2888.1	26619.1	3973848.3
1170	6006	1497.0	552.0	198.0	2916.3	27124.1	4084048.4
1180	6006	1497.0	555.0	198.0	2944.5	27634.1	4195848.3
1190	6006	1497.0	558.0	198.0	2972.7	28149.1	4309248.4
1200	6006	1497.0	561.0	198.0	3000.9	28669.1	4424248.3
1210	6006	1497.0	564.0	198.0	3029.1	29194.1	4540848.4
1220	6006	1497.0	567.0	198.0	3057.3	29724.1	4659048.3
1230	6006	1497.0	570.0	198.0	3085.5	30259.1	4778848.4
1240	6006	1497.0	573.0	198.0	3113.7	30799.1	4899248.3
1250	6006	1497.0	576.0	198.0	3141.9	31334.1	5021248.4
1260	6006	1497.0	579.0	198.0	3170.1	31874.1	5144848.3
1270	6006	1497.0	582.0	198.0	3198.3	32419.1	5269048.4
1280	6006	1497.0	585.0	198.0	3226.5	32969.1	5394848.3
1290	6006	1497.0	588.0	198.0	3254.7	33524.1	5521248.4
1300	6006	1497.0	591.0	198.0	3282.9	34084.1	5649248.3
1310	6006	1497.0	594.0	198.0	3311.1	34649.1	5778848.4
1320	6006	1497.0	597.0	198.0	3339.3	35219.1	5909048.3
1330	6006	1497.0	600.0	198.0	3367.5	35794.1	6040848.4
1340	6006	1497.0	603.0	198.0	3395.7	36374.1	6173248.3
1350	6006	1497					

TABLE 17

Effect of Sensor Axis Orientation ($\Omega = 30^\circ$)

$\Omega = 30$		$SS = 2000$		$RAPP = 6000$		$REDRNG = 3.00$	
$V0 = 1500.0$		$VGRAD = .00050$		$YDIFF = .1$			
BRGP	ACT	V2	BRGA	BRGB	ERROR	BRGT	DELTA
10	5946	1501.9	12.0	8.6	54.1	195.2	0.0
20	5975	1502.3	25.6	17.5	25.4	209.3	0.0
30	5985	1502.8	35.0	23.4	15.6	222.9	0.0
40	5990	1503.0	48.1	34.3	10.7	234.1	0.0
50	5994	1503.3	58.9	42.6	6.3	249.5	0.0
60	5995	1503.8	69.4	52.1	3.4	257.0	0.0
70	5995	1504.3	79.5	60.9	1.7	264.6	0.0
80	5995	1504.9	89.1	68.0	0.8	270.1	0.0
90	5994	1505.5	99.1	74.6	0.2	274.6	0.0
100	5991	1506.1	109.4	80.4	0.1	278.2	0.0
110	5989	1506.5	117.7	85.1	0.0	281.0	0.0
120	5985	1506.9	123.6	88.9	0.0	283.1	0.0
130	5980	1507.2	128.4	91.9	0.0	284.6	0.0
140	5970	1507.5	132.1	94.1	0.0	285.3	0.0
150	5941	1507.8	134.2	95.6	0.0	285.3	0.0
160		1508.0	135.4	96.1	0.0	284.6	0.0
170		1508.1	135.4	95.6	0.0	283.1	0.0
180		1508.1	134.2	94.1	0.0	281.0	0.0
190		1507.8	132.1	91.9	0.0	278.2	0.0
200		1507.2	128.4	88.9	0.0	274.6	0.0
210		1506.9	123.6	85.1	0.0	270.1	0.0
220		1506.5	117.7	80.4	0.0	264.6	0.0
230		1506.1	109.4	74.6	0.0	257.0	0.0
240		1505.5	99.1	68.0	0.0	249.5	0.0
250		1504.9	89.1	60.9	0.0	240.1	0.0
260		1504.3	79.5	52.1	0.0	229.5	0.0
270		1503.8	69.4	42.6	0.0	217.0	0.0
280		1503.3	58.9	34.3	0.0	202.9	0.0
290		1503.0	48.1	23.4	0.0	185.2	0.0
300		1502.8	35.0	17.5	0.0	159.3	0.0
310		1502.3	25.6	12.0	0.0	122.9	0.0
320		1502.0	12.0	8.6	0.0	75.2	0.0
330		1501.9	0.0	0.0	0.0	25.4	0.0
340		1501.8			0.0	10.7	0.0
350		1501.7			0.0	6.3	0.0
360		1501.6			0.0	3.4	0.0
370		1501.5			0.0	1.7	0.0
380		1501.4			0.0	0.8	0.0
390		1501.3			0.0	0.2	0.0
400		1501.2			0.0	0.1	0.0
410		1501.1			0.0	0.0	0.0
420		1501.0			0.0	0.0	0.0
430		1500.9			0.0	0.0	0.0
440		1500.8			0.0	0.0	0.0
450		1500.7			0.0	0.0	0.0
460		1500.6			0.0	0.0	0.0
470		1500.5			0.0	0.0	0.0
480		1500.4			0.0	0.0	0.0
490		1500.3			0.0	0.0	0.0
500		1500.2			0.0	0.0	0.0
510		1500.1			0.0	0.0	0.0
520		1500.0			0.0	0.0	0.0
530		1499.9			0.0	0.0	0.0
540		1499.8			0.0	0.0	0.0
550		1499.7			0.0	0.0	0.0
560		1499.6			0.0	0.0	0.0
570		1499.5			0.0	0.0	0.0
580		1499.4			0.0	0.0	0.0
590		1499.3			0.0	0.0	0.0
600		1499.2			0.0	0.0	0.0
610		1499.1			0.0	0.0	0.0
620		1499.0			0.0	0.0	0.0
630		1498.9			0.0	0.0	0.0
640		1498.8			0.0	0.0	0.0
650		1498.7			0.0	0.0	0.0
660		1498.6			0.0	0.0	0.0
670		1498.5			0.0	0.0	0.0
680		1498.4			0.0	0.0	0.0
690		1498.3			0.0	0.0	0.0
700		1498.2			0.0	0.0	0.0
710		1498.1			0.0	0.0	0.0
720		1498.0			0.0	0.0	0.0
730		1497.9			0.0	0.0	0.0
740		1497.8			0.0	0.0	0.0
750		1497.7			0.0	0.0	0.0
760		1497.6			0.0	0.0	0.0
770		1497.5			0.0	0.0	0.0
780		1497.4			0.0	0.0	0.0
790		1497.3			0.0	0.0	0.0
800		1497.2			0.0	0.0	0.0
810		1497.1			0.0	0.0	0.0
820		1497.0			0.0	0.0	0.0
830		1496.9			0.0	0.0	0.0
840		1496.8			0.0	0.0	0.0
850		1496.7			0.0	0.0	0.0
860		1496.6			0.0	0.0	0.0
870		1496.5			0.0	0.0	0.0
880		1496.4			0.0	0.0	0.0
890		1496.3			0.0	0.0	0.0
900		1496.2			0.0	0.0	0.0
910		1496.1			0.0	0.0	0.0
920		1496.0			0.0	0.0	0.0
930		1495.9			0.0	0.0	0.0
940		1495.8			0.0	0.0	0.0
950		1495.7			0.0	0.0	0.0
960		1495.6			0.0	0.0	0.0
970		1495.5			0.0	0.0	0.0
980		1495.4			0.0	0.0	0.0
990		1495.3			0.0	0.0	0.0
1000		1495.2			0.0	0.0	0.0
1010		1495.1			0.0	0.0	0.0
1020		1495.0			0.0	0.0	0.0
1030		1494.9			0.0	0.0	0.0
1040		1494.8			0.0	0.0	0.0
1050		1494.7			0.0	0.0	0.0
1060		1494.6			0.0	0.0	0.0
1070		1494.5			0.0	0.0	0.0
1080		1494.4			0.0	0.0	0.0
1090		1494.3			0.0	0.0	0.0
1100		1494.2			0.0	0.0	0.0
1110		1494.1			0.0	0.0	0.0
1120		1494.0			0.0	0.0	0.0
1130		1493.9			0.0	0.0	0.0
1140		1493.8			0.0	0.0	0.0
1150		1493.7			0.0	0.0	0.0
1160		1493.6			0.0	0.0	0.0
1170		1493.5			0.0	0.0	0.0
1180		1493.4			0.0	0.0	0.0
1190		1493.3			0.0	0.0	0.0
1200		1493.2			0.0	0.0	0.0
1210		1493.1			0.0	0.0	0.0
1220		1493.0			0.0	0.0	0.0
1230		1492.9			0.0	0.0	0.0
1240		1492.8			0.0	0.0	0.0
1250		1492.7			0.0	0.0	0.0
1260		1492.6			0.0	0.0	0.0
1270		1492.5			0.0	0.0	0.0
1280		1492.4			0.0	0.0	0.0
1290		1492.3			0.0	0.0	0.0
1300		1492.2			0.0	0.0	0.0
1310		1492.1			0.0	0.0	0.0
1320		1492.0			0.0	0.0	0.0
1330		1491.9			0.0	0.0	0.0
1340		1491.8			0.0	0.0	0.0
1350		1491.7			0.0	0.0	0.0
1360		1491.6			0.0	0.0	0.0
1370		1491.5			0.0	0.0	0.0
1380		1491.4			0.0	0.0	0.0
1390		1491.3			0.0	0.0	0.0
1400		1491.2			0.0	0.0	0.0
1410		1491.1			0.0	0.0	0.0
1420		1491.0			0.0	0.0	0.0
1430		1490.9			0.0	0.0	0.0
1440		1490.8			0.0	0.0	0.0
1450		1490.7			0.0	0.0	0.0
1460		1490.6			0.0	0.0	0.0
1470		1490.5			0.0	0.0	0.0
1480		1490.4			0.0	0.0	0.0
1490		1490.3			0.0	0.0	0.0
1500		1490.2			0.0	0.0	0.0
1510		1490.1			0.0	0.0	0.0
1520		1490.0			0.0	0.0	0.0
1530		1489.9			0.0	0.0	0.0
1540		1489.8			0.0	0.0	0.0
1550		1489.7			0.0	0.0	0.0
1560		1489.6			0.0	0.0	0.0
1570		1489.5			0.0	0.0	0.0
1580		1489.4			0.0	0.0	0.0
1590		1489.3			0.0	0.0	0.0
1600		1489.2			0.0	0.0	0.0
1610		1489.1			0.0	0.0	0.0
1620		1489.0			0.0	0.0	0.0
1630		1488.9			0.0	0.0	0.0
1640		1488.8			0.0	0.0	0.0
1650		1488.7			0.0	0.0	0.0
1660		1488.6			0.0	0.0	0.0
1670		1488.5			0.0	0.0	0.0
1680		1488.4			0.0	0.0	0.0
1690		1488.3			0.0	0.0	0.0
1700		1488.2			0.0	0.0	0.0
1710		1488.1			0.0	0.0	0.0
1720		1488.0			0.0	0.0	0.0
1730		1487.9			0.0	0.0	0.0
1740		1487.8			0.0	0.0	0.0
1750		1487.7			0.0	0.0	0.0
1760		1487.6			0.0	0.0	0.0
1770		1487.5			0.0	0.0	0.0
1780		1487.4			0.0	0.0	0.0
1790		1487.3			0.0	0.0	0.0
1800		1487.2			0.0	0.0	0.0
1810		1487.1			0.0	0.0	0.0
1820		1487.0			0.0	0.0	0.0
1830		1486.9			0.0	0.0	0.0
1840		1486.8			0.0	0.0	0.0
1850		1486.7			0.0	0.0	0.0
1860		1486.6			0.0	0.0	0.0

TABLE 18

Effect of Sensor Axis Orientation ($\Omega = 40^\circ$)

OMEGA = 40		SS = 2000		RAPP = 6000		REDRNG = 3.00	
VO = 1500.0		VGRAD = .00050		YDIFF = .1			
BRGP	ACT	V2	BRGA	BRGB	ERROR	BRGT	DELTA
10	5955	1502	123	8	57	195	0
20	5980	1502	135	17	22	209	0
30	5988	1503	147	25	28	228	0
40	5992	1503	158	34	31	233	0
50	5994	1503	168	43	38	238	0
60	5995	1503	179	52	44	244	0
70	5996	1502	189	61	49	249	0
80	5996	1502	199	70	56	254	0
90	5995	1501	109	80	64	258	0
100	5995	1501	118	90	72	263	0
110	5993	1501	126	100	77	268	0
120	5992	1501	136	111	83	271	0
130	5989	1500	145	123	89	274	0
140	5986	1500	154	134	96	279	0
150	5981	1499	162	144	102	284	0
160	5972	1498	171	156	109	289	0
170	5946		181	168	115	293	0
180			192	180	122	298	0
190	6048		203	192	130	303	0
200	6013		215	205	138	308	0
210	6008		227	217	146	313	0
220	6006		238	229	154	318	0
230	6004		249	241	162	323	0
240	6004		259	253	170	328	0
250	6005		269	265	178	333	0
260	6006		279	277	186	338	0
270	6007		289	289	194	343	0
280	6009		299	297	202	348	0
290	6011		309	306	210	353	0
300	6014		319	316	218	358	0
310	6019		329	324	226	363	0
320	6023		339	333	234	368	0
330	6025		348	342	242	373	0
340			351	351	250	378	0
350					255	383	0
						388	0
						393	0
						398	0
						403	0
						408	0
						413	0
						418	0
						423	0
						428	0
						433	0
						438	0
						443	0
						448	0
						453	0
						458	0
						463	0
						468	0
						473	0
						478	0
						483	0
						488	0
						493	0
						498	0
						503	0
						508	0
						513	0
						518	0
						523	0
						528	0
						533	0
						538	0
						543	0
						548	0
						553	0
						558	0
						563	0
						568	0
						573	0
						578	0
						583	0
						588	0
						593	0
						598	0
						603	0
						608	0
						613	0
						618	0
						623	0
						628	0
						633	0
						638	0
						643	0
						648	0
						653	0
						658	0
						663	0
						668	0
						673	0
						678	0
						683	0
						688	0
						693	0
						698	0
						703	0
						708	0
						713	0
						718	0
						723	0
						728	0
						733	0
						738	0
						743	0
						748	0
						753	0
						758	0
						763	0
						768	0
						773	0
						778	0
						783	0
						788	0
						793	0
						798	0
						803	0
						808	0
						813	0
						818	0
						823	0
						828	0
						833	0
						838	0
						843	0
						848	0
						853	0
						858	0
						863	0
						868	0
						873	0
						878	0
						883	0
						888	0
						893	0
						898	0
						903	0
						908	0
						913	0
						918	0
						923	0
						928	0
						933	0
						938	0
						943	0
						948	0
						953	0
						958	0
						963	0
						968	0
						973	0
						978	0
						983	0
						988	0
						993	0
						998	0
						1003	0
						1008	0
						1013	0
						1018	0
						1023	0
						1028	0
						1033	0
						1038	0
						1043	0
						1048	0
						1053	0
						1058	0
						1063	0
						1068	0
						1073	0
						1078	0
						1083	0
						1088	0
						1093	0
						1098	0
						1103	0
						1108	0
						1113	0
						1118	0
						1123	0
						1128	0
						1133	0
						1138	0
						1143	0
						1148	0
						1153	0
						1158	0
						1163	0
						1168	0
						1173	0
						1178	0
						1183	0
						1188	0
						1193	0
						1198	0
						1203	0
						1208	0
						1213	0
						1218	0
						1223	0
						1228	0
						1233	0
						1238	0
						1243	0
						1248	0
						1253	0
						1258	0
						1263	0
						1268	0
						1273	0
						1278	0
						1283	0
						1288	0
						1293	0
						1298	0
						1303	0
						1308	0
						1313	0
						1318	0
						1323	0
						1328	0
						1333	0
						1338	0
						1343	0
						1348	0
						1353	0
						1358	0
						1363	0
						1368	0
						1373	0
						1378	0
						1383	0
						1388	0
						1393	0
						1398	0
						1403	0
						1408	0
						1413	0
						1418	0
						1423	0
						1428	0
						1433	0
						1438	0
						1443	0
						1448	0
						1453	0
						1458	0
						1463	0
						1468	

TABLE 19

Effect of Sensor Axis Orientation ($\Omega = 50^\circ$)

$\Omega = 50$		SS = 2000	RAPP = 6000	REDNG = 3.00	
VO = 1500.0		VGRAD = .00050	YDIFF = .1		
BRGP	ACT	V2	BRGA	BRGB	ERROR
10	5962	1502.6	12.0	8.6	37.5
20	5984	1502.8	13.9	17.5	16.4
30	5991	1503.0	35.0	34.0	6.4
40	5994	1503.0	58.1	52.4	4.3
50	5996	1503.0	79.4	70.6	3.4
60	5997	1502.8	89.5	80.9	5.1
70	5997	1502.3	99.5	90.5	6.7
80	5996	1501.5	108.4	100.6	8.9
90	5995	1501.5	117.6	111.9	11.2
100	5994	1500.5	123.5	117.0	14.2
110	5992	1500.5	134.2	123.3	18.5
120	5990	1500.5	144.2	133.0	25.3
130	5987	1499.9	154.2	144.1	46.0
140	5983	1499.8	167.1	156.8	89.3
150	5975	1498.1	171.1	168.0	180.0
160	5954		IMPOSSIBLE		
170					
180	6040	1497.2	187.6	192.0	37.7
190	6017	1497.0	195.2	203.9	19.6
200	6009	1497.0	205.6	215.6	9.6
210	6006	1497.0	214.3	223.0	6.4
220	6004	1497.0	222.2	231.1	4.4
230	6003	1497.0	229.5	238.8	5.6
240	6003	1497.0	234.1	245.9	7.8
250	6004	1497.0	239.0	251.4	10.3
260	6005	1498.1	246.0	259.5	14.8
270	6006	1498.0	250.1	267.7	25.7
280	6008	1499.0	257.0	279.8	48.3
290	6010	1500.1	260.1	289.7	89.3
300	6013	1501.1	261.5	296.4	180.0
310	6015		303.4	307.6	
320	6017		312.2	316.5	
330	6024		324.5	324.2	
340			335.3	334.1	
350			345.1	342.8	

DELTA	RNGERR	RELEERR
0.0	37.5	0.063
0.0	16.4	0.027
0.0	6.4	0.010
0.0	4.3	0.007
0.0	3.4	0.006
0.0	5.1	0.007
0.0	6.7	0.009
0.0	8.9	0.010
0.1	11.2	0.014
0.1	14.2	0.016
0.1	18.5	0.020
0.1	25.3	0.030
0.1	46.0	0.042
0.0	89.3	0.077
0.0	180.0	0.166
0.0	37.7	0.229
0.0	19.6	0.316
0.0	9.6	0.410
0.0	6.4	0.507
0.0	4.4	0.607
0.0	5.6	0.707
0.0	7.8	0.809
0.1	10.3	0.912
0.1	14.8	1.014
0.1	25.7	1.117
0.1	48.3	1.240
0.1	89.3	1.340
0.0	180.0	1.479

BRGT	DEG
194.9	194.9
208.6	208.6
217.6	217.6
221.7	221.7
220.8	220.8
209.9	209.9
221.8	221.8
234.6	234.6
267.7	267.7
291.0	291.0
327.3	327.3
343.9	343.9
366.8	366.8
395.1	395.1
429.4	429.4
458.3	458.3
482.5	482.5
502.0	502.0
517.4	517.4
528.3	528.3
534.2	534.2
535.0	535.0
529.0	529.0
509.2	509.2
474.7	474.7
427.5	427.5
369.2	369.2
292.4	292.4
197.5	197.5
107.6	107.6
17.9	17.9
-39.1	-39.1

TABLE 20

Effect of Sensor Axis Orientation ($\Omega = 60^\circ$)

$\Omega = 60$		$SS = 2000$		$RAPP = 6000$		$REDRNG = 3.00$	
$V_0 = 1500.0$		$VGRAD = .00050$		$YDIFF = .1$			
BRGP	ACT	V2	BRGA	BRGB	ERROR	DETA	RNGERR
10	5973	1502	12.0	8.6	27.1	0.0	27.0
20	5989	1503	23.5	17.8	10.8	0.0	10.8
30	5994	1503	35.7	34.2	5.5	0.0	5.4
40	5997	1503	47.0	43.4	3.5	0.0	3.2
50	5998	1502	58.9	52.1	2.5	0.0	1.9
60	5998	1502	69.4	61.9	1.5	0.0	1.1
70	5998	1501	79.6	70.5	0.5	0.0	0.3
80	5997	1501	89.5	80.4	0.2	0.0	0.1
90	5996	1501	99.1	90.5	0.1	0.0	0.0
100	5993	1500	108.6	100.6	0.1	0.0	0.0
110	5991	1500	117.6	111.9	0.1	0.0	0.0
120	5985	1499	126.5	121.0	0.2	0.0	0.0
130	5985	1499	135.4	133.4	0.6	0.0	0.0
140	5979	1498	144.2	146.0	1.3	0.0	0.0
150	5962	1497	152.4	156.0	2.9	0.0	0.0
160		1497	161.4	168.0	5.9	0.0	0.0
170		1497	171.4	180.0	10.6	0.0	0.0
180	6012	1497	180.6	192.0	18.2	0.0	0.0
190	6006	1497	195.2	203.9	28.0	0.0	0.0
200	6003	1497	204.3	215.6	38.2	0.0	0.0
210	6002	1497	213.4	227.0	46.1	0.0	0.0
220	6002	1497	222.4	238.8	53.4	0.0	0.0
230	6002	1498	231.5	249.9	60.6	0.0	0.0
240	6003	1498	240.5	260.9	67.4	0.0	0.0
250	6004	1499	250.0	271.9	74.5	0.0	0.0
260	6007	1499	260.1	282.8	81.6	0.0	0.0
270	6009	1500	270.1	293.7	88.7	0.0	0.0
280	6011	1501	280.1	304.6	95.8	0.0	0.0
290	6015	1501	290.1	315.5	102.9	0.0	0.0
300	6021	1501	300.1	326.4	110.1	0.0	0.0
310	6028	1502	310.1	337.3	117.3	0.0	0.0
320	6035	1502	320.1	348.1	124.5	0.0	0.0
330		1502	330.1	359.0	131.8	0.0	0.0
340		1502	340.1	369.9	139.1	0.0	0.0
350		1502	350.1	380.8	146.5	0.0	0.0
360		1502	360.1	391.7	153.8	0.0	0.0

TABLE 21

Effect of Sensor Axis Orientation ($\Omega = 70^\circ$)

[illegible]

TABLE 22

Effect of Sensor Axis Orientation ($\text{OMEGA} = 80^\circ$)

OMEGA = 80		SS = 2000		RAPP = 6000		REDRNG = 3.00	
V0 = 1500.0		VGRAD = .00050		YDIFF = .1			
BRGP	RACT	V2	BRGA	BRGB	ERROR	BRGT	DELTA
10	5995	1503.0	12.0	8.6	5.2	190.4	0.0
20	6000	1503.6	23.9	17.8	1.0	102.1	0.0
30	6001	1502.6	37.0	25.6	2.5	185.0	0.0
40	6002	1502.3	47.0	34.3	4.4	97.5	0.0
50	6002	1501.9	58.4	42.4	6.3	115.6	0.0
60	6001	1501.5	68.9	52.4	9.4	133.7	0.0
70	6000	1501.0	79.4	60.5	4.8	150.6	0.0
80	5999	1500.5	89.5	70.9	2.5	171.9	0.0
90	5998	1500.0	99.1	80.4	6.6	189.7	0.0
100	5997	1499.5	109.4	90.6	9.3	207.2	0.0
110	5996	1499.0	118.6	101.9	7.7	224.6	0.0
120	5995	1498.5	127.6	111.9	6.7	242.5	0.0
130	5994	1498.0	136.4	123.4	8.9	260.3	0.0
140	5993	1497.5	145.2	134.1	7.3	278.0	0.0
150	5991	1497.0	154.0	146.0	4.8	295.4	0.0
160	5990	1497.2	162.8	156.8	3.4	312.2	0.0
170	5984	1497.7	171.4	168.0	2.1	329.3	0.0
180			180.0	180.0	1.80	346.5	0.0
190	6007	1497.0	188.6	192.9	6.8	190.3	0.0
200	5999	1497.6	197.5	203.5	1.2	141.5	0.0
210	5998	1497.4	205.4	215.7	3.4	99.3	0.0
220	5999	1497.7	213.2	227.8	5.9	116.4	0.0
230	5999	1498.0	221.1	239.9	4.4	134.3	0.0
240	5999	1498.5	229.0	252.2	8.2	153.1	0.0
250	6000	1499.0	237.0	264.9	5.9	170.8	0.0
260	6001	1499.5	245.0	277.9	3.9	188.7	0.0
270	6003	1500.0	253.0	289.8	6.6	206.6	0.0
280	6004	1500.5	261.0	301.6	7.7	224.7	0.0
290	6006	1501.0	269.0	313.5	9.6	242.5	0.0
300	6009	1501.5	277.0	325.4	6.6	260.3	0.0
310	6011	1502.0	285.0	337.5	1.8	278.0	0.0
320	6019	1502.2	293.0	349.1		295.4	0.0
330		1502.4	301.0	360.4		312.2	0.0
340		1502.6	309.0	371.8		329.3	0.0
350		1502.8	317.0	383.4		346.5	0.0
360		1503.0	325.0	395.0		363.7	0.0
370		1503.2	333.0	406.7		380.9	0.0
380		1503.4	341.0	418.4		398.1	0.0
390		1503.6	349.0	430.1		415.3	0.0
400		1503.8	357.0	441.8		432.5	0.0
410		1504.0	365.0	453.4		449.7	0.0
420		1504.2	373.0	465.0		466.9	0.0
430		1504.4	381.0	476.7		484.1	0.0
440		1504.6	389.0	488.4		501.3	0.0
450		1504.8	397.0	500.1		518.5	0.0
460		1505.0	405.0	511.8		535.7	0.0
470		1505.2	413.0	523.4		552.9	0.0
480		1505.4	421.0	535.0		570.1	0.0
490		1505.6	429.0	546.7		587.3	0.0
500		1505.8	437.0	558.4		604.5	0.0
510		1506.0	445.0	570.1		621.7	0.0
520		1506.2	453.0	581.8		638.9	0.0
530		1506.4	461.0	593.4		656.1	0.0
540		1506.6	469.0	605.0		673.3	0.0
550		1506.8	477.0	616.7		690.5	0.0
560		1507.0	485.0	628.4		707.7	0.0
570		1507.2	493.0	640.1		724.9	0.0
580		1507.4	501.0	651.8		742.1	0.0
590		1507.6	509.0	663.4		759.3	0.0
600		1507.8	517.0	675.0		776.5	0.0
610		1508.0	525.0	686.7		793.7	0.0
620		1508.2	533.0	698.4		810.9	0.0
630		1508.4	541.0	710.1		828.1	0.0
640		1508.6	549.0	721.8		845.3	0.0
650		1508.8	557.0	733.4		862.5	0.0
660		1509.0	565.0	745.0		879.7	0.0
670		1509.2	573.0	756.7		896.9	0.0
680		1509.4	581.0	768.4		914.1	0.0
690		1509.6	589.0	780.1		931.3	0.0
700		1509.8	597.0	791.8		948.5	0.0
710		1510.0	605.0	803.4		965.7	0.0
720		1510.2	613.0	815.0		982.9	0.0
730		1510.4	621.0	826.7		1000.1	0.0
740		1510.6	629.0	838.4		1017.3	0.0
750		1510.8	637.0	850.1		1034.5	0.0
760		1511.0	645.0	861.8		1051.7	0.0
770		1511.2	653.0	873.4		1068.9	0.0
780		1511.4	661.0	885.0		1086.1	0.0
790		1511.6	669.0	896.7		1103.3	0.0
800		1511.8	677.0	908.4		1120.5	0.0
810		1512.0	685.0	920.1		1137.7	0.0
820		1512.2	693.0	931.8		1154.9	0.0
830		1512.4	701.0	943.4		1172.1	0.0
840		1512.6	709.0	955.0		1189.3	0.0
850		1512.8	717.0	966.7		1206.5	0.0
860		1513.0	725.0	978.4		1223.7	0.0
870		1513.2	733.0	990.1		1240.9	0.0
880		1513.4	741.0	1001.8		1258.1	0.0
890		1513.6	749.0	1013.4		1275.3	0.0
900		1513.8	757.0	1025.0		1292.5	0.0
910		1514.0	765.0	1036.7		1309.7	0.0
920		1514.2	773.0	1048.4		1326.9	0.0
930		1514.4	781.0	1060.1		1344.1	0.0
940		1514.6	789.0	1071.8		1361.3	0.0
950		1514.8	797.0	1083.4		1378.5	0.0
960		1515.0	805.0	1095.0		1395.7	0.0
970		1515.2	813.0	1106.7		1412.9	0.0
980		1515.4	821.0	1118.4		1430.1	0.0
990		1515.6	829.0	1130.1		1447.3	0.0
1000		1515.8	837.0	1141.8		1464.5	0.0
1010		1516.0	845.0	1153.4		1481.7	0.0
1020		1516.2	853.0	1165.0		1498.9	0.0
1030		1516.4	861.0	1176.7		1516.1	0.0
1040		1516.6	869.0	1188.4		1533.3	0.0
1050		1516.8	877.0	1200.1		1550.5	0.0
1060		1517.0	885.0	1211.8		1567.7	0.0
1070		1517.2	893.0	1223.4		1584.9	0.0
1080		1517.4	901.0	1235.0		1602.1	0.0
1090		1517.6	909.0	1246.7		1619.3	0.0
1100		1517.8	917.0	1258.4		1636.5	0.0
1110		1518.0	925.0	1270.1		1653.7	0.0
1120		1518.2	933.0	1281.8		1670.9	0.0
1130		1518.4	941.0	1293.4		1688.1	0.0
1140		1518.6	949.0	1305.0		1705.3	0.0
1150		1518.8	957.0	1316.7		1722.5	0.0
1160		1519.0	965.0	1328.4		1739.7	0.0
1170		1519.2	973.0	1340.1		1756.9	0.0
1180		1519.4	981.0	1351.8		1774.1	0.0
1190		1519.6	989.0	1363.4		1791.3	0.0
1200		1519.8	997.0	1375.0		1808.5	0.0
1210		1520.0	1005.0	1386.7		1825.7	0.0
1220		1520.2	1013.0	1398.4		1842.9	0.0
1230		1520.4	1021.0	1410.1		1860.1	0.0
1240		1520.6	1029.0	1421.8		1877.3	0.0
1250		1520.8	1037.0	1433.4		1894.5	0.0
1260		1521.0	1045.0	1445.0		1911.7	0.0
1270		1521.2	1053.0	1456.7		1928.9	0.0
1280		1521.4	1061.0	1468.4		1946.1	0.0
1290		1521.6	1069.0	1480.1		1963.3	0.0
1300		1521.8	1077.0	1491.8		1980.5	0.0
1310		1522.0	1085.0	1503.4		1997.7	0.0
1320		1522.2	1093.0	1515.0		2014.9	0.0
1330		1522.4	1101.0	1526.7		2032.1	0.0
1340		1522.6	1109.0	1538.4		2049.3	0.0
1350		1522.8	1117.0	1550.1		2066.5	0.0
1360		1523.0	1125.0	1561.8		2083.7	0.0
1370		1523.2	1133.0	1573.4		2100.9	0.0
1380		1523.4	1141.0	1585.0		2118.1	0.0
1390		1523.6	1149.0	1596.7		2135.3	0.0
1400		1523.8	1157.0	1608.4		2152.5	0.0
1410		1524.0	1165.0	1620.1		2169.7	0.0
1420		1524.2	1173.0	1631.8		2186.9	0.0
1430		1524.4	1181.0	1643.4		2204.1	0.0
1440		1524.6	1189.0	1655.0		2221.3	0.0
1450		1524.8	1197.0	1666.7		2238.5	0.0
1460		1525.0	1205.0	1678.4		2255.7	0.0
1470		1525.2	1213.0	1690.1		2272.9	0.0
1480		1525.4	1221.0	1701.8		2290.1	0.0
1490		1525.6	1229.0	1713.4		2307.3	0.0
1500		1525.8	1237.0	1725.0		2324.5	0.0
1510		1526.0	1245.0	1736.7		2341.7	0.0
1520		1526.2	1253.0	1748.4		2358.9	0.0
1530		1526.4	1261.0	1760.1		2376.1	0.0
1540		1526.6	1269.0	1771.8		2393.3	0.0
1550		1526.8	1277.0	1783.4		2410.5	0.0
1560		1527.0	1285.0	1795.0		2427.7	0.0
1570		1527.2	1293.0	1806.7		2444.9	0.0
1580		1527.4	1301.0	1818.4		2462.1	0.0
1590		1527.6	1309.0	1830.1		2479.3	0.0
1600		1527.8	1317.0	1841.8		2496.5	0.0
1610		1528.0	1325.0	1853.4		2513.7</	

TABLE 23

Effect of Sensor Axis Orientation ($\Omega = 90^\circ$)

$\Omega = 90$		$\Omega = 2000$		$\Omega = 6000$		$\Omega = 3.00$	
$V_0 = 1500.0$		$V_{GRAD} = .00050$		$V_{DIFF} = .1$		$V_{DIFF} = .1$	
BRGP	RACT	V2	BRGA	BRGB	ERROR	BRGT	DELTA
10	6006	502	123	8	53	197	-0
20	6006	502	35	17	6	39	-0
30	6005	502	47	23	5	1	-0
40	6005	501	58	43	6	81	-0
50	6004	501	68	52	6	1	-0
60	6002	501	79	61	6	10	-0
70	6001	500	89	70	6	11	-0
80	6000	500	99	80	6	16	-0
90	5999	499	109	90	6	18	-0
100	5998	498	118	100	6	19	-0
110	5997	498	127	110	6	22	-0
120	5996	498	136	120	6	23	-0
130	5995	497	145	130	6	25	-0
140	5995	497	154	140	5	27	-0
150	5995	497	162	150	5	28	-0
160	5995	497	171	160	5	33	-0
170	5995	497	180	170	5	38	-0
180	5995	497	188	180	5	44	-0
190	5995	497	197	190	5	46	-0
200	5995	497	205	200	5	48	-0
210	5996	497	214	210	5	51	-0
220	5996	498	223	220	5	53	-0
230	5997	498	231	230	5	56	-0
240	5998	499	240	240	5	59	-0
250	5999	500	250	250	5	62	-0
260	6000	500	260	260	5	66	-0
270	6001	501	270	270	5	69	-0
280	6002	501	280	280	5	71	-0
290	6003	501	290	290	5	73	-0
300	6004	502	300	300	5	78	-0
310	6005	502	310	310	5	80	-0
320	6006	503	320	320	5	84	-0
330	6006	503	330	330	5	88	-0
340	6006	503	340	340	5	91	-0
350	6006	503	350	350	5	97	-0
360	6006	503	360	360	5	100	-0
370	6006	503	370	370	5	104	-0
380	6006	503	380	380	5	108	-0
390	6006	503	390	390	5	112	-0
400	6006	503	400	400	5	116	-0
410	6006	503	410	410	5	120	-0
420	6006	503	420	420	5	124	-0
430	6006	503	430	430	5	128	-0
440	6006	503	440	440	5	132	-0
450	6006	503	450	450	5	136	-0
460	6006	503	460	460	5	140	-0
470	6006	503	470	470	5	144	-0
480	6006	503	480	480	5	148	-0
490	6006	503	490	490	5	152	-0
500	6006	503	500	500	5	156	-0
510	6006	503	510	510	5	160	-0
520	6006	503	520	520	5	164	-0
530	6006	503	530	530	5	168	-0
540	6006	503	540	540	5	172	-0
550	6006	503	550	550	5	176	-0
560	6006	503	560	560	5	180	-0
570	6006	503	570	570	5	184	-0
580	6006	503	580	580	5	188	-0
590	6006	503	590	590	5	192	-0
600	6006	503	600	600	5	196	-0
610	6006	503	610	610	5	200	-0
620	6006	503	620	620	5	204	-0
630	6006	503	630	630	5	208	-0
640	6006	503	640	640	5	212	-0
650	6006	503	650	650	5	216	-0
660	6006	503	660	660	5	220	-0
670	6006	503	670	670	5	224	-0
680	6006	503	680	680	5	228	-0
690	6006	503	690	690	5	232	-0
700	6006	503	700	700	5	236	-0
710	6006	503	710	710	5	240	-0
720	6006	503	720	720	5	244	-0
730	6006	503	730	730	5	248	-0
740	6006	503	740	740	5	252	-0
750	6006	503	750	750	5	256	-0
760	6006	503	760	760	5	260	-0
770	6006	503	770	770	5	264	-0
780	6006	503	780	780	5	268	-0
790	6006	503	790	790	5	272	-0
800	6006	503	800	800	5	276	-0
810	6006	503	810	810	5	280	-0
820	6006	503	820	820	5	284	-0
830	6006	503	830	830	5	288	-0
840	6006	503	840	840	5	292	-0
850	6006	503	850	850	5	296	-0
860	6006	503	860	860	5	300	-0
870	6006	503	870	870	5	304	-0
880	6006	503	880	880	5	308	-0
890	6006	503	890	890	5	312	-0
900	6006	503	900	900	5	316	-0
910	6006	503	910	910	5	320	-0
920	6006	503	920	920	5	324	-0
930	6006	503	930	930	5	328	-0
940	6006	503	940	940	5	332	-0
950	6006	503	950	950	5	336	-0
960	6006	503	960	960	5	340	-0
970	6006	503	970	970	5	344	-0
980	6006	503	980	980	5	348	-0
990	6006	503	990	990	5	352	-0
1000	6006	503	1000	1000	5	356	-0
1010	6006	503	1010	1010	5	360	-0
1020	6006	503	1020	1020	5	364	-0
1030	6006	503	1030	1030	5	368	-0
1040	6006	503	1040	1040	5	372	-0
1050	6006	503	1050	1050	5	376	-0
1060	6006	503	1060	1060	5	380	-0
1070	6006	503	1070	1070	5	384	-0
1080	6006	503	1080	1080	5	388	-0
1090	6006	503	1090	1090	5	392	-0
1100	6006	503	1100	1100	5	396	-0
1110	6006	503	1110	1110	5	400	-0
1120	6006	503	1120	1120	5	404	-0
1130	6006	503	1130	1130	5	408	-0
1140	6006	503	1140	1140	5	412	-0
1150	6006	503	1150	1150	5	416	-0
1160	6006	503	1160	1160	5	420	-0
1170	6006	503	1170	1170	5	424	-0
1180	6006	503	1180	1180	5	428	-0
1190	6006	503	1190	1190	5	432	-0
1200	6006	503	1200	1200	5	436	-0
1210	6006	503	1210	1210	5	440	-0
1220	6006	503	1220	1220	5	444	-0
1230	6006	503	1230	1230	5	448	-0
1240	6006	503	1240	1240	5	452	-0
1250	6006	503	1250	1250	5	456	-0
1260	6006	503	1260	1260	5	460	-0
1270	6006	503	1270	1270	5	464	-0
1280	6006	503	1280	1280	5	468	-0
1290	6006	503	1290	1290	5	472	-0
1300	6006	503	1300	1300	5	476	-0
1310	6006	503	1310	1310	5	480	-0
1320	6006	503	1320	1320	5	484	-0
1330	6006	503	1330	1330	5	488	-0
1340	6006	503	1340	1340	5	492	-0
1350	6006	503	1350	1350	5	496	-0
1360	6006	503	1360	1360	5	500	-0
1370	6006	503	1370	1370	5	504	-0
1380	6006	503	1380	1380	5	508	-0
1390	6006	503	1390	1390	5	512	-0
1400	6006	503	1400	1400	5	516	-0
1410	6006	503	1410	1410	5	520	-0
1420	6006	503	1420	1420	5	524	-0
1430	6006	503	1430	1430	5	528	-0
1440	6006	503	1440	1440	5	532	-0
1450	6006	503	1450	1450	5	536	-0
1460	6006	503	1460	1460	5	540	-0
1470	6006	503	1470	1470	5	544	-0
1480	6006	503	1480	1480	5	548	-0
1490	6006	503	1490	1490	5	552	-0
1500	6006	503	1500	1500	5	556	-0
1510	6006	503	1510	1510	5	560	-0
1520	6006	503	1520	1520	5	564	-0
1530	6006	503	1530	1530	5	568	-0
1540	6006	503	1540	1540	5	572	-0
1550	6006	503	1550	1550	5	576	-0
1560	6006	503	1560	1560	5	580	-0
1570	6006	503	1570	1570	5	584	-0
1580	6006	503	1580	1580	5	588	-0
1590	6006	503	1590	1590	5	592	-0
1600	6006	503	1600	1600	5	596	-0
1610	6006	503	1610	1610	5	600	-0
1620	6006	503	1620	1620	5	604	-0
1630	6006	503	1630	1630	5	608	-0
1640	6006	503	1640	1640	5	612	-0
1650	6006	503	1650	1650	5	616	-0
1660	6006	503	1660	1660	5	620	-0
1670	6006	503	1670	1670	5	624	-0
1680	6006	503	1680	1680	5	628	-0
1690	6006	503	1690	1690	5	632	-0
1700	6006	503	1700	1700	5	636	-0
1710	6006	503	1710	1710	5	640	-0
1720	6006	503	1720	1720	5	644	-0
1730	6006	503	1730	1730	5	648	-0
1740	6006	503	1740	1740	5	652	-0
1750	6006	503	1750	1750	5	656	-0

TABLE 24

Effects at Reduced Range Equal to 1.25 (OMEGA = 90°)

OMEGA = 90		SS = 400000		RAPP = 500000		REDRNG = 1.25	
VO = 1500.0		VGRAD = .00010		YDIFF = .1			
BRGP	RACT	V2	BRGA	BRGB	ERROR	DEGT	RNGERR
10	507129	1547.5	16.5	7.3	73394	2.4	7129
20	506826	1547.3	47.0	4.6	75983	6.7	6826
30	506541	1533.8	62.3	9.3	82566	9.0	6541
40	506253	1521.4	78.4	3.7	88295	0.0	6253
50	505965	1509.9	92.1	8.2	95670	1.1	5965
60	505677	1499.0	108.6	1.5	99407	1.1	5677
70	505389	1488.4	128.3	6.7	99292	0.8	5389
80	505101	1477.5	143.1	0.6	98403	0.5	5101
90	504813	1467.0	158.5	0.5	97537	8.7	4813
100	504525	1456.1	172.9	0.5	96681	5.4	4525
110	504237	1445.1	187.3	1.3	95825	4.2	4237
120	503949	1434.2	196.5	3.5	94969	2.2	3949
130	503661	1423.3	212.7	0.3	94113	5.7	3661
140	503373	1412.4	227.0	4.4	93257	8.0	3373
150	503085	1401.5	242.3	5.5	92401	0.0	3085
160	502797	1390.6	257.5	4.5	91545	1.1	2797
170	502509	1379.7	272.8	9.8	90689	1.1	2509
180	502221	1368.8	289.1	2.3	89833	0.9	2221
190	501933	1357.9	308.0	0.8	88977	1.1	1933
200	501645	1347.0	323.1	1.7	88121	0.9	1645
210	501357	1336.1	338.5	1.4	87265	7.6	1357
220	501069	1325.2	353.8	7.9	86409	4.2	1069
230	500781	1314.3	369.1	4.7	85553	1.2	781
240	500493	1303.4	384.4	5.9	84697	0.3	493
250	500205	1292.5	399.7	2.3	83841	0.5	205
260	500000	1281.6	415.0	0.8	82985	1.5	000
270	499795	1270.7	430.3	1.7	82129	0.6	795
280	499590	1259.8	445.6	1.1	81273	0.5	590
290	499385	1248.9	460.9	7.9	80417	0.6	385
300	499180	1238.0	476.2	4.4	79561	0.5	180
310	498975	1227.1	491.5	5.5	78705	0.6	975
320	498770	1216.2	506.8	2.3	77849	0.5	770
330	498565	1205.3	522.1	0.8	76993	0.6	565
340	498360	1194.4	537.4	1.7	76137	0.5	360
350	498155	1183.5	552.7	7.9	75281	0.6	155
360	497950	1172.6	568.0	4.4	74425	0.5	950
370	497745	1161.7	583.3	5.5	73569	0.6	745
380	497540	1150.8	598.6	2.3	72713	0.5	540
390	497335	1139.9	613.9	0.8	71857	0.6	335
400	497130	1129.0	629.2	1.7	71001	0.5	130
410	496925	1118.1	644.5	7.9	70145	0.6	925
420	496720	1107.2	659.8	4.4	69289	0.5	720
430	496515	1096.3	675.1	5.5	68433	0.6	515
440	496310	1085.4	690.4	2.3	67577	0.5	310
450	496105	1074.5	705.7	0.8	66721	0.6	105
460	495900	1063.6	721.0	1.7	65865	0.5	900
470	495695	1052.7	736.3	7.9	65009	0.6	695
480	495490	1041.8	751.6	4.4	64153	0.5	490
490	495285	1030.9	766.9	5.5	63297	0.6	285
500	495080	1020.0	782.2	2.3	62441	0.5	800
510	494875	1009.1	797.5	0.8	61585	0.6	595
520	494670	998.2	812.8	1.7	60729	0.5	390
530	494465	987.3	828.1	7.9	59873	0.6	185
540	494260	976.4	843.4	4.4	59017	0.5	900
550	494055	965.5	858.7	5.5	58161	0.6	695
560	493850	954.6	874.0	2.3	57305	0.5	490
570	493645	943.7	889.3	0.8	56449	0.6	285
580	493440	932.8	904.6	1.7	55593	0.5	800
590	493235	921.9	919.9	7.9	54737	0.6	595
600	493030	911.0	935.2	4.4	53881	0.5	390
610	492825	900.1	950.5	5.5	53025	0.6	185
620	492620	889.2	965.8	2.3	52169	0.5	900
630	492415	878.3	981.1	0.8	51313	0.6	695
640	492210	867.4	996.4	1.7	50457	0.5	490
650	492005	856.5	1011.7	7.9	49601	0.6	285
660	491800	845.6	1027.0	4.4	48745	0.5	800
670	491595	834.7	1042.3	5.5	47889	0.6	595
680	491390	823.8	1057.6	2.3	47033	0.5	390
690	491185	812.9	1072.9	0.8	46177	0.6	185
700	490980	802.0	1088.2	1.7	45321	0.5	900
710	490775	791.1	1103.5	7.9	44465	0.6	695
720	490570	780.2	1118.8	4.4	43609	0.5	490
730	490365	769.3	1134.1	5.5	42753	0.6	285
740	490160	758.4	1149.4	2.3	41897	0.5	800
750	489955	747.5	1164.7	0.8	41041	0.6	595
760	489750	736.6	1180.0	1.7	40185	0.5	390
770	489545	725.7	1195.3	7.9	39329	0.6	185
780	489340	714.8	1210.6	4.4	38473	0.5	900
790	489135	703.9	1225.9	5.5	37617	0.6	695
800	488930	693.0	1241.2	2.3	36761	0.5	490
810	488725	682.1	1256.5	0.8	35905	0.6	285
820	488520	671.2	1271.8	1.7	35049	0.5	800
830	488315	660.3	1287.1	7.9	34193	0.6	595
840	488110	649.4	1302.4	4.4	33337	0.5	390
850	487905	638.5	1317.7	5.5	32481	0.6	185
860	487700	627.6	1333.0	2.3	31625	0.5	900
870	487495	616.7	1348.3	0.8	30769	0.6	695
880	487290	605.8	1363.6	1.7	29913	0.5	490
890	487085	594.9	1378.9	7.9	29057	0.6	285
900	486880	584.0	1394.2	4.4	28201	0.5	800
910	486675	573.1	1409.5	5.5	27345	0.6	595
920	486470	562.2	1424.8	2.3	26489	0.5	390
930	486265	551.3	1440.1	0.8	25633	0.6	185
940	486060	540.4	1455.4	1.7	24777	0.5	900
950	485855	529.5	1470.7	7.9	23921	0.6	695
960	485650	518.6	1486.0	4.4	23065	0.5	490
970	485445	507.7	1501.3	5.5	22209	0.6	285
980	485240	496.8	1516.6	2.3	21353	0.5	800
990	485035	485.9	1531.9	0.8	20497	0.6	595
1000	484830	475.0	1547.2	1.7	19641	0.5	390

TABLE 25

Effects at Reduced Range Equal to .5 (OMEGA = 0°)

OMEGA =	0	SS = 400000	RAPP = 200000	YDIFF = .1	REDRNG = .50
	V0 = 1500.0	VGRAD = .00010			
BRGP	10			DELTA	RNGERR
10	1502.9	95.0	BRGT	1.4	593
20	1506.3	100.0	275.0	1.3	584
30	1509.4	110.0	279.0	1.2	571
40	1512.0	115.0	284.0	1.0	555
50	1514.9	120.0	287.0	1.0	521
60	1517.0	125.0	289.0	1.0	496
70	1518.4	130.0	289.0	1.0	476
80	1519.5	135.0	286.0	1.0	458
90	1519.5	140.0	279.0	1.0	438
100	1518.7	145.0	270.0	1.0	413
110	1517.4	150.0	265.0	1.0	382
120	1514.9	155.0	255.0	1.0	346
130	1509.6	160.0	250.0	1.0	307
140	1502.2	165.0	245.0	1.0	265
150	1502.2	170.0	245.0	1.0	219
160	1502.2	175.0	245.0	1.0	169
170	1502.2	180.0	245.0	1.0	115
180	1492.6	185.0	245.0	1.0	59
190	1489.9	190.0	245.0	1.0	3
200	1486.4	195.0	245.0	1.0	45
210	1482.0	200.0	245.0	1.0	120
220	1488.0	205.0	245.0	1.0	207
230	1488.0	210.0	245.0	1.0	334
240	1488.0	215.0	245.0	1.0	463
250	1488.0	220.0	245.0	1.0	593
260	1488.0	225.0	245.0	1.0	726
270	1488.0	230.0	245.0	1.0	864
280	1488.0	235.0	245.0	1.0	1007
290	1488.0	240.0	245.0	1.0	1155
300	1488.0	245.0	245.0	1.0	1308
310	1488.0	250.0	245.0	1.0	1466
320	1488.0	255.0	245.0	1.0	1629
330	1488.0	260.0	245.0	1.0	1797
340	1488.0	265.0	245.0	1.0	1970
350	1488.0	270.0	245.0	1.0	2148
360	1488.0	275.0	245.0	1.0	2331
370	1488.0	280.0	245.0	1.0	2519
380	1488.0	285.0	245.0	1.0	2712
390	1488.0	290.0	245.0	1.0	2910
400	1488.0	295.0	245.0	1.0	3114
410	1488.0	300.0	245.0	1.0	3324
420	1488.0	305.0	245.0	1.0	3539
430	1488.0	310.0	245.0	1.0	3759
440	1488.0	315.0	245.0	1.0	3984
450	1488.0	320.0	245.0	1.0	4214
460	1488.0	325.0	245.0	1.0	4449
470	1488.0	330.0	245.0	1.0	4689
480	1488.0	335.0	245.0	1.0	4934
490	1488.0	340.0	245.0	1.0	5184
500	1488.0	345.0	245.0	1.0	5439
510	1488.0	350.0	245.0	1.0	5699
520	1488.0	355.0	245.0	1.0	5964
530	1488.0	360.0	245.0	1.0	6234
540	1488.0	365.0	245.0	1.0	6509
550	1488.0	370.0	245.0	1.0	6789
560	1488.0	375.0	245.0	1.0	7074
570	1488.0	380.0	245.0	1.0	7364
580	1488.0	385.0	245.0	1.0	7659
590	1488.0	390.0	245.0	1.0	7959
600	1488.0	395.0	245.0	1.0	8264
610	1488.0	400.0	245.0	1.0	8574
620	1488.0	405.0	245.0	1.0	8889
630	1488.0	410.0	245.0	1.0	9209
640	1488.0	415.0	245.0	1.0	9534
650	1488.0	420.0	245.0	1.0	9864
660	1488.0	425.0	245.0	1.0	10199
670	1488.0	430.0	245.0	1.0	10754
680	1488.0	435.0	245.0	1.0	11319
690	1488.0	440.0	245.0	1.0	11894
700	1488.0	445.0	245.0	1.0	12479
710	1488.0	450.0	245.0	1.0	13074
720	1488.0	455.0	245.0	1.0	13679
730	1488.0	460.0	245.0	1.0	14294
740	1488.0	465.0	245.0	1.0	14919
750	1488.0	470.0	245.0	1.0	15554
760	1488.0	475.0	245.0	1.0	16199
770	1488.0	480.0	245.0	1.0	16854
780	1488.0	485.0	245.0	1.0	17519
790	1488.0	490.0	245.0	1.0	18194
800	1488.0	495.0	245.0	1.0	18879
810	1488.0	500.0	245.0	1.0	19574
820	1488.0	505.0	245.0	1.0	20279
830	1488.0	510.0	245.0	1.0	20994
840	1488.0	515.0	245.0	1.0	21719
850	1488.0	520.0	245.0	1.0	22454
860	1488.0	525.0	245.0	1.0	23199
870	1488.0	530.0	245.0	1.0	23954
880	1488.0	535.0	245.0	1.0	24719
890	1488.0	540.0	245.0	1.0	25494
900	1488.0	545.0	245.0	1.0	26279
910	1488.0	550.0	245.0	1.0	27074
920	1488.0	555.0	245.0	1.0	27879
930	1488.0	560.0	245.0	1.0	28694
940	1488.0	565.0	245.0	1.0	29519
950	1488.0	570.0	245.0	1.0	30354
960	1488.0	575.0	245.0	1.0	31199
970	1488.0	580.0	245.0	1.0	32054
980	1488.0	585.0	245.0	1.0	32919
990	1488.0	590.0	245.0	1.0	33794
1000	1488.0	595.0	245.0	1.0	34679
1010	1488.0	600.0	245.0	1.0	35574
1020	1488.0	605.0	245.0	1.0	36479
1030	1488.0	610.0	245.0	1.0	37394
1040	1488.0	615.0	245.0	1.0	38319
1050	1488.0	620.0	245.0	1.0	39254
1060	1488.0	625.0	245.0	1.0	40199
1070	1488.0	630.0	245.0	1.0	41154
1080	1488.0	635.0	245.0	1.0	42119
1090	1488.0	640.0	245.0	1.0	43094
1100	1488.0	645.0	245.0	1.0	44079
1110	1488.0	650.0	245.0	1.0	45074
1120	1488.0	655.0	245.0	1.0	46079
1130	1488.0	660.0	245.0	1.0	47094
1140	1488.0	665.0	245.0	1.0	48119
1150	1488.0	670.0	245.0	1.0	49154
1160	1488.0	675.0	245.0	1.0	50199
1170	1488.0	680.0	245.0	1.0	51254
1180	1488.0	685.0	245.0	1.0	52319
1190	1488.0	690.0	245.0	1.0	53394
1200	1488.0	695.0	245.0	1.0	54479
1210	1488.0	700.0	245.0	1.0	55574
1220	1488.0	705.0	245.0	1.0	56679
1230	1488.0	710.0	245.0	1.0	57794
1240	1488.0	715.0	245.0	1.0	58919
1250	1488.0	720.0	245.0	1.0	60054
1260	1488.0	725.0	245.0	1.0	61199
1270	1488.0	730.0	245.0	1.0	62354
1280	1488.0	735.0	245.0	1.0	63519
1290	1488.0	740.0	245.0	1.0	64694
1300	1488.0	745.0	245.0	1.0	65879
1310	1488.0	750.0	245.0	1.0	67074
1320	1488.0	755.0	245.0	1.0	68279
1330	1488.0	760.0	245.0	1.0	69494
1340	1488.0	765.0	245.0	1.0	70719
1350	1488.0	770.0	245.0	1.0	71954
1360	1488.0	775.0	245.0	1.0	73199
1370	1488.0	780.0	245.0	1.0	74454
1380	1488.0	785.0	245.0	1.0	75719
1390	1488.0	790.0	245.0	1.0	76994
1400	1488.0	795.0	245.0	1.0	78279
1410	1488.0	800.0	245.0	1.0	79574
1420	1488.0	805.0	245.0	1.0	80879
1430	1488.0	810.0	245.0	1.0	82194
1440	1488.0	815.0	245.0	1.0	83519
1450	1488.0	820.0	245.0	1.0	84854
1460	1488.0	825.0	245.0	1.0	86199
1470	1488.0	830.0	245.0	1.0	87554
1480	1488.0	835.0	245.0	1.0	88919
1490	1488.0	840.0	245.0	1.0	90294
1500	1488.0	845.0	245.0	1.0	91679
1510	1488.0	850.0	245.0	1.0	93074
1520	1488.0	855.0	245.0	1.0	94479
1530	1488.0	860.0	245.0	1.0	95894
1540	1488.0	865.0	245.0	1.0	97319
1550	1488.0	870.0	245.0	1.0	98754
1560	1488.0	875.0	245.0	1.0	100199
1570	1488.0	880.0	245.0	1.0	101854
1580	1488.0	885.0	245.0	1.0	103519
1590	1488.0	890.0	245.0	1.0	105194
1600	1488.0	895.0	245.0	1.0	106879
1610	1488.0	900.0	245.0	1.0	108574
1620	1488.0	905.0	245.0	1.0	110279
1630	1488.0	910.0	245.0	1.0	111994
1640	1488.0	915.0	245.0	1.0	113719
1650	1488.0	920.0	245.0	1.0	115454
1660	1488.0	925.0	245.0	1.0	117199
1670	1488.0	930.0	245.0	1.0	118954
1680	1488.0	935.0	245.0	1.0	120719
1690	1488.0	940.0	245.0	1.0	122494
1700	1488.0	945.0	245.0	1.0	124279
1710	1488.0	950.0	245.0	1.0	126074
1720	1488.0	955.0	245.0	1.0	127879
1730	1488.0	960.0	245.0	1.0	129694
1740	1488.0	965.0	245.0	1.0	131519
1750	1488.0	970.0	245.0	1.0	133354
1760	1488.0	975.0	245.0	1.0	135199
1770	1488.0	980.0	245.0	1.0	137054
1780	1488.0	985.0	245.0	1.0	138919
1790	1488.0	990.0	245.0	1.0	140794
1800	1488.0	995.0	245.0	1.0	142679
1810	1488.0	1000.0	245.0	1.0	144574
1820	1488.0	1005.0	245.0	1.0	146479
1830	1488.0	1010.0	245.0	1.0	148394
1840	1488.0	1015.0	245.0	1.0	150319
1850	1488.0	1020.0	245.0	1.0	152254
1860	1488.0	1025.0	245.0	1.0	154199
1870	1488.0	1030.0	245.0	1.0	156154
1880	1488.0	1035.0	245.0	1.0	158119
1890	1488.0	1040.0	245.0	1.0	160094
1900	1488.0	1045.0	245.0	1.0	162079
1910	1488.0	1050.0	245.0	1.0	164074
1920	148				

TABLE 26

Effects at Reduced Range Equal to .5 (OMEGA = 90°)

OMEGA = 90	SS = 400000	RAPP = 200000	REDRNG = .50
V0 = 1500.0	VGRAD = .00010	YDIFF = .1	
BRGP	BRGA	BRGB	ERROR
10	1519.7	5.0	469
20	1518.3	10.0	924
30	1517.5	20.0	1332
40	1515.2	30.0	1706
50	1509.6	40.0	2031
60	1503.9	50.0	2258
70	1496.2	60.0	2437
80	1487.9	70.0	2565
90	1481.0	80.0	2649
100	1480.0	90.0	2694
110	1487.9	100.0	2718
120	1488.2	110.0	2731
130	1488.1	120.0	2741
140	1488.1	130.0	2748
150	1488.1	140.0	2751
160	1488.1	150.0	2751
170	1488.1	160.0	2751
180	1488.1	170.0	2751
190	1488.1	180.0	2751
200	1488.1	190.0	2751
210	1488.1	200.0	2751
220	1488.1	210.0	2751
230	1488.1	220.0	2751
240	1488.1	230.0	2751
250	1488.1	240.0	2751
260	1488.1	250.0	2751
270	1488.1	260.0	2751
280	1488.1	270.0	2751
290	1488.1	280.0	2751
300	1488.1	290.0	2751
310	1488.1	300.0	2751
320	1488.1	310.0	2751
330	1488.1	320.0	2751
340	1488.1	330.0	2751
350	1488.1	340.0	2751
360	1488.1	350.0	2751
370	1488.1	360.0	2751
380	1488.1	370.0	2751
390	1488.1	380.0	2751
400	1488.1	390.0	2751
410	1488.1	400.0	2751
420	1488.1	410.0	2751
430	1488.1	420.0	2751
440	1488.1	430.0	2751
450	1488.1	440.0	2751
460	1488.1	450.0	2751
470	1488.1	460.0	2751
480	1488.1	470.0	2751
490	1488.1	480.0	2751
500	1488.1	490.0	2751
510	1488.1	500.0	2751
520	1488.1	510.0	2751
530	1488.1	520.0	2751
540	1488.1	530.0	2751
550	1488.1	540.0	2751
560	1488.1	550.0	2751
570	1488.1	560.0	2751
580	1488.1	570.0	2751
590	1488.1	580.0	2751
600	1488.1	590.0	2751
610	1488.1	600.0	2751
620	1488.1	610.0	2751
630	1488.1	620.0	2751
640	1488.1	630.0	2751
650	1488.1	640.0	2751
660	1488.1	650.0	2751
670	1488.1	660.0	2751
680	1488.1	670.0	2751
690	1488.1	680.0	2751
700	1488.1	690.0	2751
710	1488.1	700.0	2751
720	1488.1	710.0	2751
730	1488.1	720.0	2751
740	1488.1	730.0	2751
750	1488.1	740.0	2751
760	1488.1	750.0	2751
770	1488.1	760.0	2751
780	1488.1	770.0	2751
790	1488.1	780.0	2751
800	1488.1	790.0	2751
810	1488.1	800.0	2751
820	1488.1	810.0	2751
830	1488.1	820.0	2751
840	1488.1	830.0	2751
850	1488.1	840.0	2751
860	1488.1	850.0	2751
870	1488.1	860.0	2751
880	1488.1	870.0	2751
890	1488.1	880.0	2751
900	1488.1	890.0	2751
910	1488.1	900.0	2751
920	1488.1	910.0	2751
930	1488.1	920.0	2751
940	1488.1	930.0	2751
950	1488.1	940.0	2751
960	1488.1	950.0	2751
970	1488.1	960.0	2751
980	1488.1	970.0	2751
990	1488.1	980.0	2751
1000	1488.1	990.0	2751
1010	1488.1	1000.0	2751
1020	1488.1	1010.0	2751
1030	1488.1	1020.0	2751
1040	1488.1	1030.0	2751
1050	1488.1	1040.0	2751
1060	1488.1	1050.0	2751
1070	1488.1	1060.0	2751
1080	1488.1	1070.0	2751
1090	1488.1	1080.0	2751
1100	1488.1	1090.0	2751
1110	1488.1	1100.0	2751
1120	1488.1	1110.0	2751
1130	1488.1	1120.0	2751
1140	1488.1	1130.0	2751
1150	1488.1	1140.0	2751
1160	1488.1	1150.0	2751
1170	1488.1	1160.0	2751
1180	1488.1	1170.0	2751
1190	1488.1	1180.0	2751
1200	1488.1	1190.0	2751
1210	1488.1	1200.0	2751
1220	1488.1	1210.0	2751
1230	1488.1	1220.0	2751
1240	1488.1	1230.0	2751
1250	1488.1	1240.0	2751
1260	1488.1	1250.0	2751
1270	1488.1	1260.0	2751
1280	1488.1	1270.0	2751
1290	1488.1	1280.0	2751
1300	1488.1	1290.0	2751
1310	1488.1	1300.0	2751
1320	1488.1	1310.0	2751
1330	1488.1	1320.0	2751
1340	1488.1	1330.0	2751
1350	1488.1	1340.0	2751
1360	1488.1	1350.0	2751
1370	1488.1	1360.0	2751
1380	1488.1	1370.0	2751
1390	1488.1	1380.0	2751
1400	1488.1	1390.0	2751
1410	1488.1	1400.0	2751
1420	1488.1	1410.0	2751
1430	1488.1	1420.0	2751
1440	1488.1	1430.0	2751
1450	1488.1	1440.0	2751
1460	1488.1	1450.0	2751
1470	1488.1	1460.0	2751
1480	1488.1	1470.0	2751
1490	1488.1	1480.0	2751
1500	1488.1	1490.0	2751
1510	1488.1	1500.0	2751
1520	1488.1	1510.0	2751
1530	1488.1	1520.0	2751
1540	1488.1	1530.0	2751
1550	1488.1	1540.0	2751
1560	1488.1	1550.0	2751
1570	1488.1	1560.0	2751
1580	1488.1	1570.0	2751
1590	1488.1	1580.0	2751
1600	1488.1	1590.0	2751
1610	1488.1	1600.0	2751
1620	1488.1	1610.0	2751
1630	1488.1	1620.0	2751
1640	1488.1	1630.0	2751
1650	1488.1	1640.0	2751
1660	1488.1	1650.0	2751
1670	1488.1	1660.0	2751
1680	1488.1	1670.0	2751
1690	1488.1	1680.0	2751
1700	1488.1	1690.0	2751
1710	1488.1	1700.0	2751
1720	1488.1	1710.0	2751
1730	1488.1	1720.0	2751
1740	1488.1	1730.0	2751
1750	1488.1	1740.0	2751
1760	1488.1	1750.0	2751
1770	1488.1	1760.0	2751
1780	1488.1	1770.0	2751
1790	1488.1	1780.0	2751
1800	1488.1	1790.0	2751
1810	1488.1	1800.0	2751
1820	1488.1	1810.0	2751
1830	1488.1	1820.0	2751
1840	1488.1	1830.0	2751
1850	1488.1	1840.0	2751
1860	1488.1	1850.0	2751
1870	1488.1	1860.0	2751
1880	1488.1	1870.0	2751
1890	1488.1	1880.0	2751
1900	1488.1	1890.0	2751
1910	1488.1	1900.0	2751
1920	1488.1	1910.0	2751
1930	1488.1	1920.0	2751
1940	1488.1	1930.0	2751
1950	1488.1	1940.0	2751
1960	1488.1	1950.0	2751
1970	1488.1	1960.0	2751
1980	1488.1	1970.0	2751
1990	1488.1	1980.0	2751
2000	1488.1	1990.0	2751
2010	1488.1	2000.0	2751
2020	1488.1	2010.0	2751
2030	1488.1	2020.0	2751
2040	1488.1	2030.0	2751
2050	1488.1	2040.0	2751
2060	1488.1	2050.0	2751
2070	1488.1	2060.0	2751
2080	1488.1	2070.0	2751
2090	1488.1	2080.0	2751
2100	1488.1	2090.0	2751
2110	1488.1	2100.0	2751
2120	1488.1	2110.0	2751
2130	1488.1	2120.0	2751
2140	1488.1	2130.0	2751
2150	1488.1	2140.0	2751
2160	1488.1	2150.0	2751
2170	1488.1	2160.0	2751
2180	1488.1	2170.0	2751
2190	1488.1	2180.0	2751
2200	1488.1	2190.0	2751
2210	1488.1	2200.0	2751
2220	1488.1	2210.0	2751
2230	1488.1	2220.0	2751
2240	1488.1	2230.0	2751
2250	1488.1	2240.0	2751
2260	1488.1	2250.0	2751
2270	1488.1	2260.0	2751
2280	1488.1	2270.0	2751
2290	1488.1	2280.0	2751
2300	1488.1	2290.0	2751
2310	1488.1	2300.0	2751
2320	1488.1	2310.0	2751
2330	1488.1	2320.0	2751
2340	1488.1	2330.0	2751
2350	1488.1	2340.0	2751
2360	1488.1	2350.0	2751
2370	1488.1	2360.0	2751
2380	1488.1	2370.0	2751
2390	1488.1	2380.0	2751
2400	1488.1	2390.0	2751
2410	1488.1	2400.0	2751
2420	1488.1	2410.0	2751
2430	1488.1	2420.0	2751
2440	1488.1	2430.0	2751
2450	1488.1	2440.0	2751
2460	1488.1	2450.0	2751
2470	1488.1	2460.0	2751
2480	1488.1	2470.0	2751
2490	1488.1	2480.0	2751
2500	1488.1	2490.0	2751
2510	1488.1	2500.0	2751
2520	1488.1	2510.0	2751
2530	1488.1	2520.0	2751
2540	1488.1	2530.0	2751
2550	1488.1	2540.0	2751
2560	1488.1	2550.0	2751
2570	1488.1	2560.0	2751
2580	1488.1	2570.0	2751
2590	1488.1	2580.0	2751
2600	1488.1	2590.0	2751
2610	1488.1	2600.0	2751
2620	1488.1	2610.0	2751
2630	1488.1	2620.0	2751
2640	1488.1	2630.0	2751
2650	1488.1	2640.0	2751
2660	1488.1	2650.0	2751
2670	1488.1	2660.0	2751
2680	1488.1	2670.0	2751

TABLE 27

Effects at Reduced Range Equal to .2 (OMEGA = 0°)

OMEGA =	0	SS = 400000	RAPP = 80000	YDIFF = .1	REDRNG = .20
VO = 1500.0		VGRAD = .00010			
BRGP					
10	94767	BRGA	15397	DELTA	RELERR
20	85875	173:07	15397	2:86	19254
30	82876	1167:3	47185	2:22	00590
40	80122	1159:6	35282	2:22	00448
50	79364	1156:5	22826	2:22	00383
60	78559	1156:5	12873	2:22	00230
70	78559	1158:7	16236	2:22	00209
80	78555	1158:7	15276	2:22	00238
90	78555	1159:3	18275	2:22	00234
100	78555	1161:3	22355	2:22	00238
110	78555	1166:8	35275	2:22	00234
120	78555	1171:4	47149	2:22	00234
130	78555	1174:1	53978	2:22	00234
140	78555	1177:1	53978	2:22	00234
150	78555	1177:1	53978	2:22	00234
160	78555	1177:1	53978	2:22	00234
170	78555	1177:1	53978	2:22	00234
180	78555	1177:1	53978	2:22	00234
190	78555	1177:1	53978	2:22	00234
200	78555	1177:1	53978	2:22	00234
210	78555	1177:1	53978	2:22	00234
220	78555	1177:1	53978	2:22	00234
230	78555	1177:1	53978	2:22	00234
240	78555	1177:1	53978	2:22	00234
250	78555	1177:1	53978	2:22	00234
260	78555	1177:1	53978	2:22	00234
270	78555	1177:1	53978	2:22	00234
280	78555	1177:1	53978	2:22	00234
290	78555	1177:1	53978	2:22	00234
300	78555	1177:1	53978	2:22	00234
310	78555	1177:1	53978	2:22	00234
320	78555	1177:1	53978	2:22	00234
330	78555	1177:1	53978	2:22	00234
340	78555	1177:1	53978	2:22	00234
350	78555	1177:1	53978	2:22	00234

TABLE 28

Effects at Reduced Range Equal to .2 (OMEGA = 90°)

OMEGA = 90	SS = 400000	RAPP = 80000	REDRNG = .20
VO = 1500.0	VGRAD = .00010	YDIFF = .1	
BRGP			
10			
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14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
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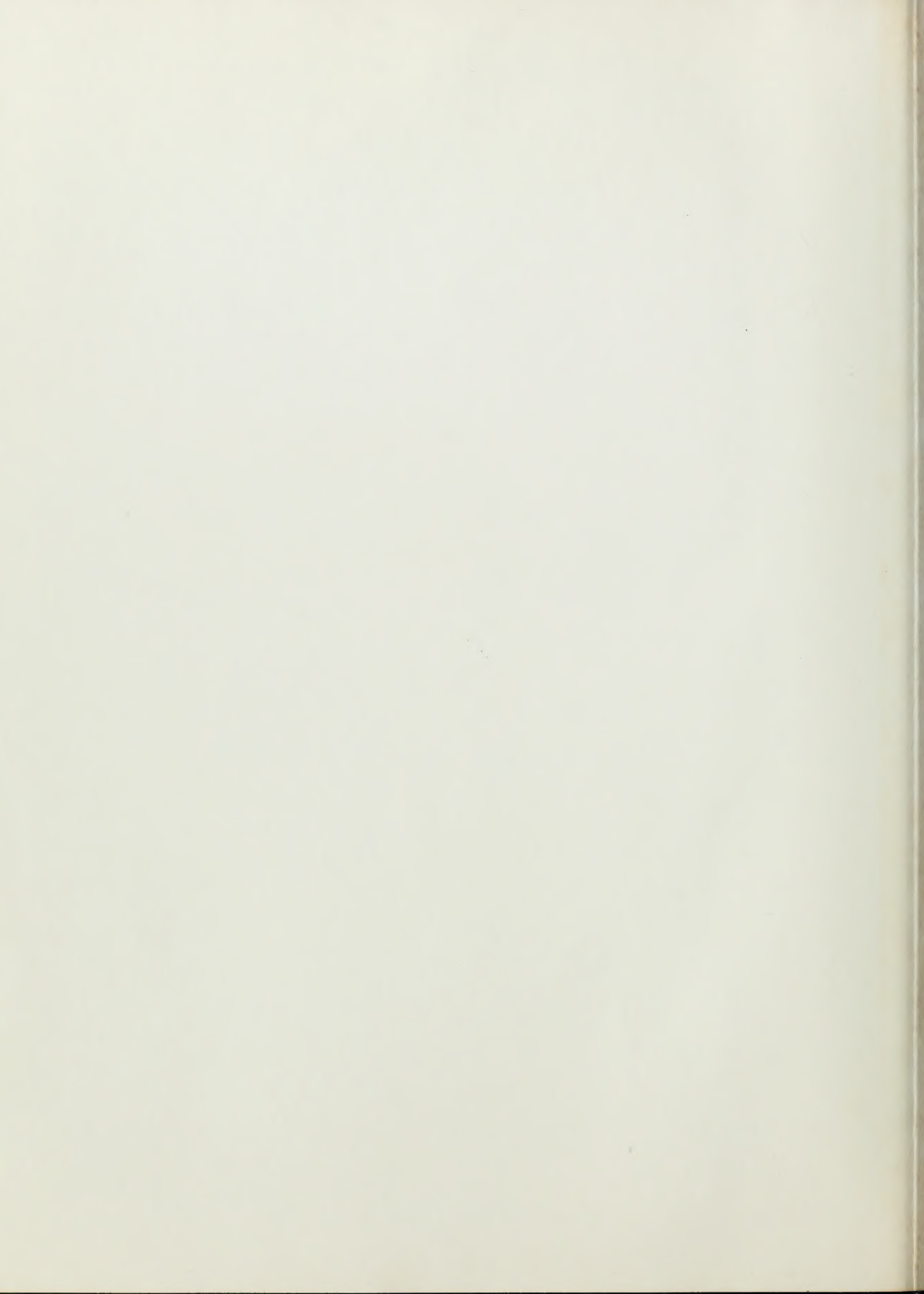
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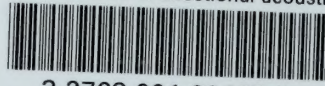
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